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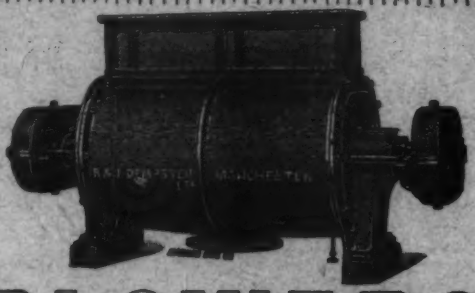

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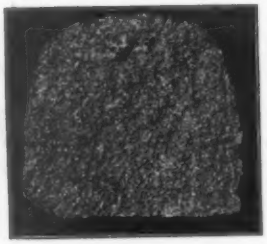
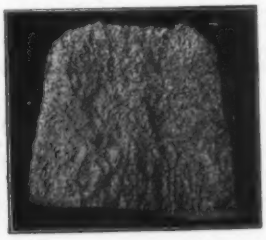
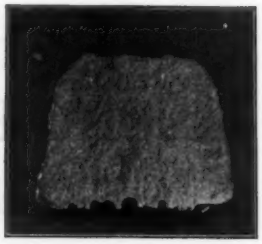

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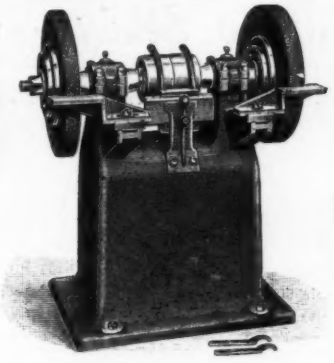

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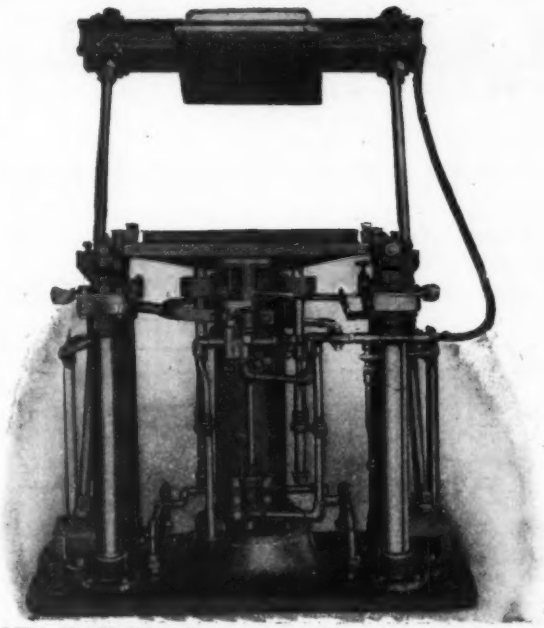

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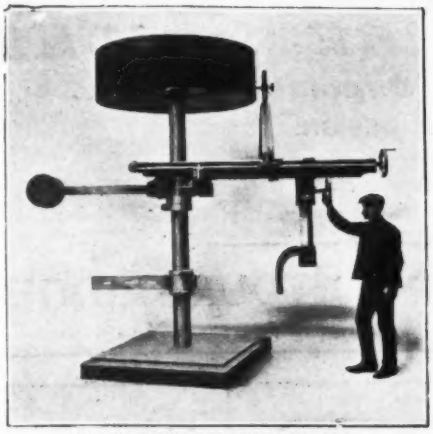

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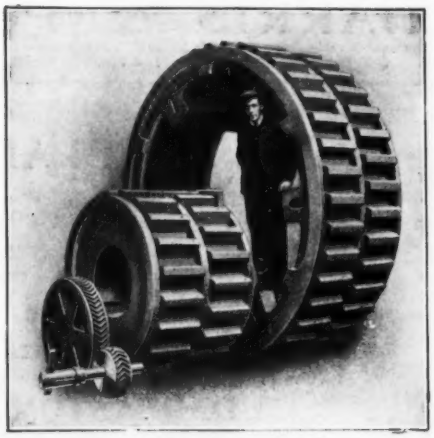

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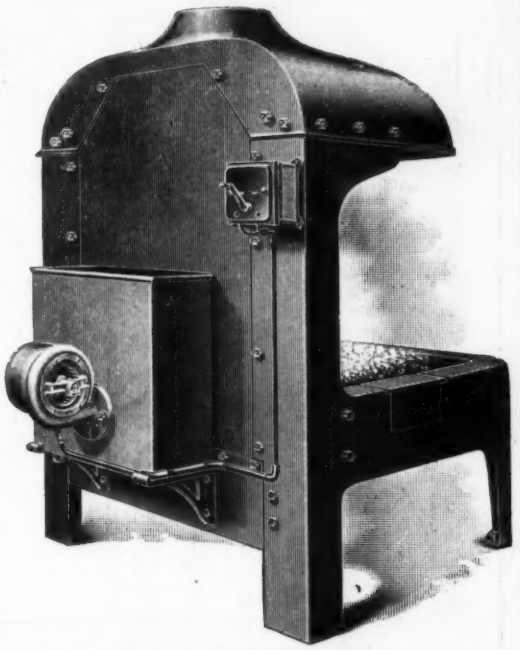

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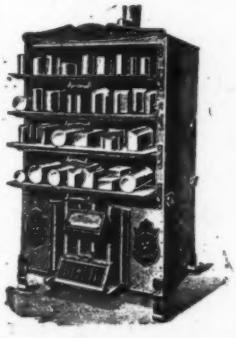

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Gentlemen,

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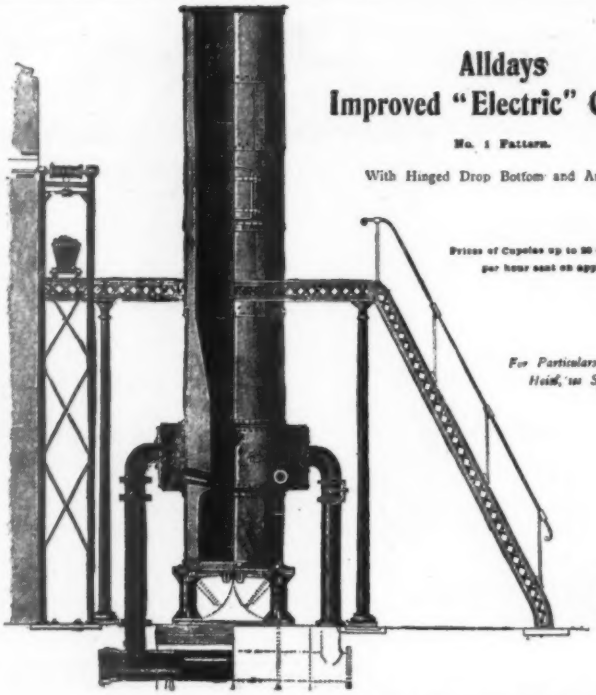

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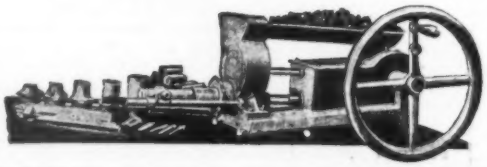

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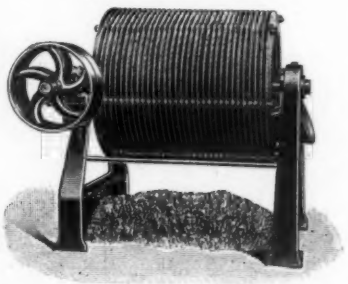

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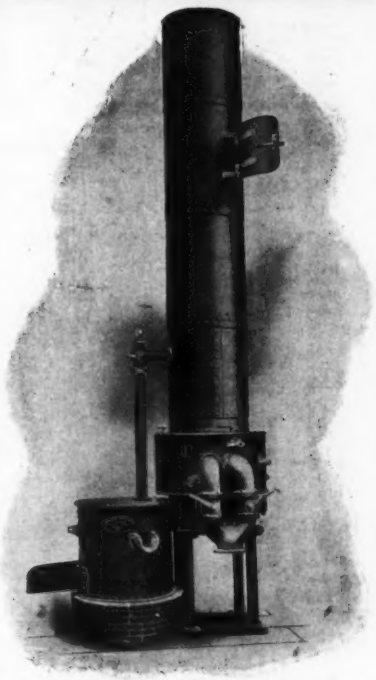
**Charging Platforms, Hoists, and Ladles.**



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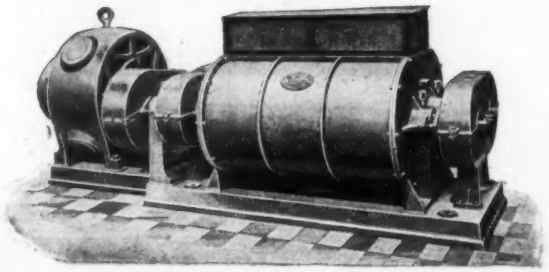

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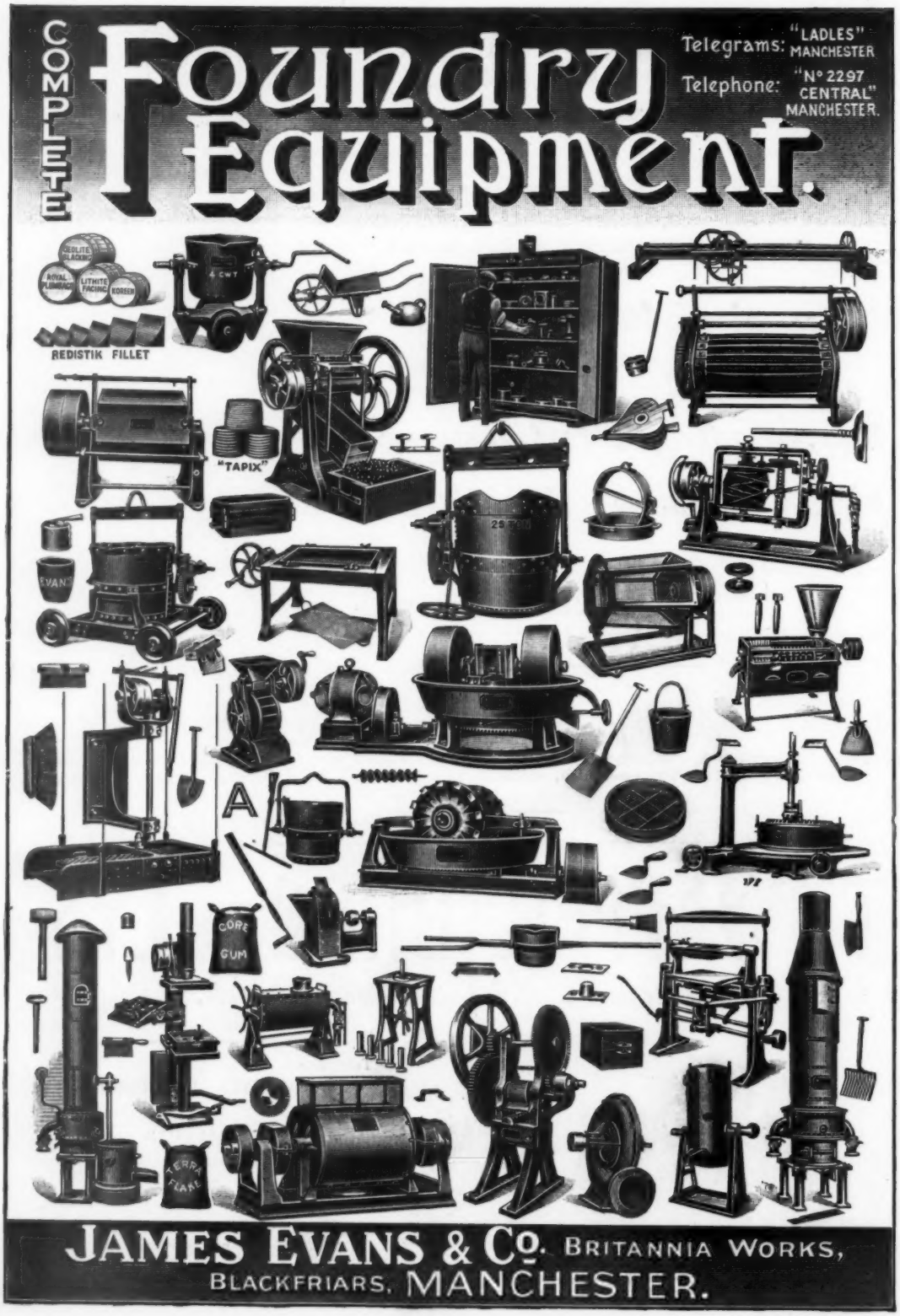
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# The Foundry Trade Journal
## AND PATTERN-MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

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## Forthcoming Events.

JANUARY 12.

*British Foundrymen's Association* (London Branch).—"Growth of Cast Iron," by Prof. Carpenter, M.A., Ph.D.

JANUARY 13.

*British Foundrymen's Association* (Lancashire Branch).—Fourth annual dinner.

*British Foundrymen's Association* (Scottish Branch).—Problem night, open meeting.

JANUARY 23.

*British Foundrymen's Association* (Sheffield Branch).—Annual meeting.

JANUARY 27.

*British Foundrymen's Association* (Birmingham Branch).—"Some Facts as to the Action of Vanadium on Cast Iron," by J. Kent Smith.

FEBRUARY 3.

*British Foundrymen's Association* (Lancashire Branch).—"Pellets and Segregation in Iron Castings," by E. L. Rhead.

## NOTES AND COMMENTS.

### The Year that's Awa'.

From an industrial standpoint the year 1911 has been one of fairly steady progress in most trades, and with few exceptions, all branches of the iron and steel trades have participated. General engineering has been fairly prosperous, and since no labour difficulties occurred in the shipbuilding industry, that department showed a production that was considerably in excess of the output for 1910, when the yards were nearly all at a standstill for almost a third of the year. The remarkable activity of the shipbuilding industry has been one of the most prominent and satisfactory features of trade in the North of England and in Scotland, and it has given the necessary impetus to the improvement in so many branches of the iron and steel trades. Pig-iron producers, it is true, have not been so fortunately situated. Indeed, the experience of the Cleveland ironmasters has been somewhat unique, and the general consensus of opinion is that over-production has been the chief cause of the unsatisfactory and mostly unprofitable pig-iron prices. The surplus of pig-iron produced went largely into the public stores, with the result that the regulation of prices was put more into the hands of speculators, whose operations adversely affected the market, from the makers' point of view. From the iron-users' standpoint, however, the year has not exhibited such a cheerless aspect, and the founder has, in most centres, been well occupied. Pipefounders in the Cleveland district particularly have had an active year, as also have those who turn out castings for shipbuilders, but prices have shown very little change. The fact that the stimulus to business was experienced towards the latter end of the year should augur well for the present year, and hopes are entertained that a steady and maintained upward movement will be experienced.

### The Future Foundry.

Predictions have often been hazarded by different authorities as to the ultimate course foundry developments will take, as regards melting apparatus in particular. While the coke-fired cupola has the field at the moment, there are not a few who see in oil fuel the coming means of melting metals of all sorts, and the results that have been attained in various quarters bear out many of the claims put forward for oil. A rival, however, appears in the form of high-pressure gas, and here again very good results are quoted in the interests of that fuel. But electricity, without question, holds out the greater possibilities; and as in the case of the steel maker, it is probable that the ease of operation, the capacity of utilising comparatively poor raw materials, and the close regulation of the product to any desired grade of refinement which is associated with the electric furnace, will place that apparatus in the front rank as a foundry melter and refiner. The application of electricity, however, is not confined to furnace work; in fact, it is first finding a field as a power for general operations. As a power for crane work, for example, it

affords important facilities, and if the electro-magnet be added an extremely useful auxiliary is available. It is computed by one authority that a foundry melting 35 tons of metal daily can install both a crane and a magnet, and expect a return upon the investment, after allowing all charges, of more than 30 per cent., and if a foundry is already equipped with either an electric or locomotive crane a magnet can then be installed on a very profitable basis when the tonnage to be handled is considerably less. For instance, assuming that a foundry melts 20 tons daily, and that a magnet be installed on an existing crane, it is calculated that the return would be more than 100 per cent. on the investment.

### General Application of Electricity.

In connection with the general application of electricity to foundry work, some interesting figures were recently quoted by Mr. B. Wiley, of Pittsburg, Pa., dealing with foundries with capacities ranging from 1,500 tons to 2,000 tons per month. The figures were based on the operations of modern foundries producing a wide range of castings, varying from 100 to 100,000 lbs., with an average of 250 lbs. The usual power employed in the plants in question was 220-volt direct-currrent, and the plant taking power averaged about as follows:—Floor motors, one 75 h.p. air-compressor, one 20-h.p. cold saw, two 30-h.p. sand mills, eight 5-h.p. grinders, six machine-shop motors of together 50 h.p., one 25-h.p. repair-shop motor, and six miscellaneous motors of together 58 h.p., making a total of 323 h.p. The crane motors two of 50 tons each (280 h.p.), three of 25 tons each (250 h.p.), four of 10 tons each (180 h.p.), and two of 5 tons each (90 h.p.) had a total of 800 h.p., and the crane-hoist motors a total of 400 h.p. The writer gave as a general rule for power-house capacities that the average load will be approximately one-half of the total capacities of floor motors and crane-hoist motors. "In figuring the crane load on the power station it is to be noted that as the hoisting motion of the crane gives the heaviest load, and as it is seldom that more than one motion is used at a time, it is sufficient to consider the load on this motor only. As the crane work is very intermittent the load is very fluctuating, and the total capacity of power generators should not be less than twice the average load. As a general rule, a spare generating unit will prove a paying investment to insure ample power at all times. For the above conditions the average power house-load is $723 \div 3 = 241$ h.p. $= 180\frac{3}{4}$-kw., and two 175-kw. generators would be sufficient. Or, figured on another basis, it requires approximately 35-kw.-hours per ton of steel castings, and approximately 45-kw.-hours per ton of iron castings, for foundries ranging in capacity as given above. The blast for the cupolas of the iron foundry and the greater amount of small work increases the electric power per ton output." The values given for power-house capacities include power for lamps and other auxiliaries, such as electric welding for the steel foundries, repair shop and pattern shop.

### Conditions of Application.

As regards the general conditions, the author just quoted established that (1) the capacity of the floor or constant-speed motors is approximately equal to the capacity of the crane-hoist motors; (2) the average station load equals one-half the total capacity of floor motors and crane-hoist motors; (3) the maximum station load equals approximately twice the average load; (4) the average distance for distribution of power is 600 ft. or less; (5) the applications of varying-speed motors are few except where considerable machine work is done, in which case the power required will seldom be over 15 per cent. of the total station capacity; and (6) the lighting load will average from 10 to 12 per cent. of the total load.

As to the question of direct current *versus* alternating current, it is pointed out that for the small plant, with a power station capacity of 300 to 500 kw., and an average distributing distance of approximately 600 ft., the 250-volt, direct-current system offers many advantages. However, if a foundry has its own power plant the cost of generating power is high on account of the rapidly fluctuating load. A central station, being of large capacity, would not feel the direct effects of the load fluctuations, and in small works, especially, power supply companies can often offer good inducements to purchase power. Lighting is the principal load of the central station, and alternating current is mostly adopted owing to the economy of distribution. In the case of an existing plant having direct-current motors installed, a rotary converter could be used to convert the power to direct current of suitable voltage. For new installations it is more economical to use the alternating current direct, although in a majority of the cases it will be necessary to reduce the voltage. Usually the transmission voltage will be over 1,000 volts, and transformers can then be used to give 240 volts for distribution within the foundry, the latter voltage being considered as most suitable for such use.

## Industrial Pyrometers.

### The Value of Cheap Pyrometers.

By C. E. Foster.

At a meeting of members of the Sheffield Branch of the British Foundrymen's Association, held recently, Mr. Charles E. Foster, of Letchworth, lectured on "Inexpensive Pyrometers," the lecture being illustrated by diagrams and demonstrations. Mr. Percy Longmuir, B.Met., President of the Branch, occupied the chair.

Mr. Foster remarked that the selection of inexpensive pyrometers became one of increasing importance to the industrial world each year. The increasing stringency of specifications made careful measurement much more essential. He believed that pyrometers would play an important part in the workshop and the foundry in the future, and in saying that he did not desire to refer specially to the one which he had designed. He was speaking of pyrometers generally. In the selection of pyrometers for research work, cost was not of much importance because of the great necessity for securing extreme accuracy. But it was different with the foundry and the shop. The thermo-couple was extensively known and was widely used, and justly so. There were many metals and alloys which could be chosen to make the thermo-couples, but when they looked for one which would give them a reliable pyrometer the choice was much narrower. The choice could be divided into rare metal and base metal—rare platinum and similar metals, and cheap metals. In the first instance, it was generally thought that a pyrometer could not be successfully made out of base metals. But platinum pyrometers would not make satisfactory industrial tools unless one was prepared to give considerable care to them—more care than could be usually given to them by the men who should be using them. If they were handled in a rough-and-ready way, they would soon go wrong.

The lecturer pointed out many difficulties which had to be met with in the pyrometer. He submitted

that it was well, if possible, to so design the pyrometer that if it did not give the right force, it would give no force at all, or, at any rate, such a result that there could be no mistake made. He referred to the excellent work done by Bristol and Hoskins.

In making a choice of base metals, they would find the choice very wide, but there were many pitfalls, and these had discouraged many inventors. The accuracy required, however, was not so high as that of the laboratory. There were many advantages in using base metal for industrial work. It was cheap to make and cheap to keep up. The cost of replacement was small, and the same special care in its use was not needed. It might need some little overlooking now and again, but it would not want watching with the care that a pyrometer would need in which the fine metals were used.

The lecturer then dealt with the various kinds of base-metal pyrometers, and gave experiments and illustrations. He dealt with optical pyrometers, and in conclusion appealed to manufacturers and others in the industrial world not to be too conservative about new devices. They might not be perfect, but they might be helpful. They could not tell what they could accomplish until they had tried them. They would certainly find that the base-metal pyrometer would yield results far better than had been generally anticipated. (Hear, hear.)

The PRESIDENT remarked that some of the instruments described by the lecturer were of the greatest interest to all of them, and especially to those employed in the steel industry. He had been very much struck with the fixed-focus pyrometer. It required little or no imagination to see the extent of its application. Mr. Foster referred to the rolling of steel. He had had the advantage of testing the fixed focus pyrometer for that purpose, and testing it against all sorts of standard conditions, and had found it extremely useful. In his opening remarks, Mr. Foster referred to the expensive and the cheaper types of pyrometers. As he truly stated, in laboratory work, for research, where extreme accuracy was required, expense was of very little moment. But those of them who had used expensive instruments knew that when they got them into the works they were certainly not shop tools. Even when these instruments were placed in the hands of trained assistants, they would go wrong. But the development of these base-metal couples, due, first of all, to Bristol and later Hoskins, had given them something which in every way could be used as shop tools. When they went wrong, simply a new thermo-couple was put on at the expense of a few shillings, and the work went on again. Bristol and Hoskins had given to the industrial world instruments which could be used by the men in the shop. They might require a little personal supervision occasionally from the laboratory, but the fact remained that they could be used by the man who really needed their assistance. And if they went wrong at all, they usually went absolutely wrong. The error was so great that the man on the job could easily detect it. He agreed with the lecturer as to the more constant use of the pyrometer. This meant more successful work. The pyrometer would not stop bad workmanship, nor would it necessarily mean good workmanship; but it was an important guide, and with it they could certainly hope to obtain more uniform results.

MR. ALLISON (Staveley) said he had had an opportunity of using Mr. Foster's instrument, and comparing it with optical instruments, and, it seemed to him that one of the main values of Mr. Foster's instrument was that the flame between the object whose temperature they wished to ascertain and the instrument did not seriously affect the result obtained. He tried Mr. Foster's instrument and also an optical instrument on a Bessemer flame. The gases did not seem to affect Mr. Foster's instrument at all, but in the case of the optical instrument one did not get quite such good results. So far as the measurement of furnace temperatures was concerned, he was fully convinced that as they got the black-body conditions they got very accurate readings by means of the mirror system.

MR. W. H. DYSON remarked that one heard nothing but praise for Mr. Foster's fixed-focus pyrometer, but as regarded base-metal couples he was not quite sure that he could say the same. Mr. Foster made a good point in regard to the cost in comparison with the more expensive couples, but when one came to think that even after 325 hours a base-metal couple would break down, the question of cost was one to be seriously considered. The ordinary platinum couple, 3 ft., would run them altogether into about £5. He forgot exactly the cost of Mr. Foster's base-metal couple, but for that length it would probably run into something like one guinea. With careful working a rare metal couple would last sometimes two years, that, of course, depending on the man in charge. Apart from this the rare metal had a value afterwards. As scrap it might make 16s. or 17s. He would like to know from Mr. Foster whether he could give the relative cost of each—taking these points into consideration—and the life of each. The fixed-focus pyrometer struck him as being a very useful instrument indeed. He had tested one and the results were most satisfactory.

The PRESIDENT said his personal experience was that base-metal couples, according to temperatures, had run from three to nine months, and even longer, in consecutive use. The life was largely dependent upon the temperature.

MR. FOSTER, replying to the discussion, asked first how long the life of a platinum instrument would be if exposed to the rough usage which a base metal instrument could stand. He was dealing with the industrial life of these instruments, and as a commercial proposition the life and cost of a base-metal pyrometer would compare most favourably with that of a platinum-rhodium. The actual life of any instrument must, of course, depend on the conditions under which it was used. With great care platinum-rhodium would, of course, give good service. But he attacked it on every point, because it required so much care. With skill and care they could, of course, get a long life out of a platinum instrument; but one knock and they might put the platinum couple out of action. He thought those of base metal deserved a trial. They could get good results and there was not that necessity for exercising care, while they could be used by the man at the job, and he would secure great advantage.

The PRESIDENT, in moving thanks to Mr. Foster for his Paper, and to his colleagues for assisting him in his demonstrations, remarked that the Paper and the demonstrations had shown them at any rate how useful a base-metal pyrometer would be in the shop. When they had a valuable instrument which they kept in a glass case, and only brought out on special occasions, it was not likely to be of much service to the man who was doing the work. He was the man who would benefit if a stronger instrument was brought into the shop, and one that he could use at any time to test the work he was doing.

MR. J. J. CROWTHER, who seconded the vote of thanks, said that if a pyrometer could be put on the market at a low price they would find it in the smaller foundries as well as in the large works. It was undoubtedly very necessary that they should know at what temperature their castings were being made.

# Blast-Furnace Gases in the Foundry.*

### Gas-Fired Drying Ovens.

When charcoal, coke, briquettes or coal are used for the purpose of drying foundry moulds, these are frequently dirtied by the ashes, etc., and it consequently becomes difficult to obtain uniform drying. The use of producer gas for the same purpose allows the formation of soot or tar deposit in the gas pipes, in consequence of which a special gas has to be generated for this purpose, if gas is to be used at all. Both methods, however, are too expensive for general use. The employment of blast-furnace gas for mould drying has the advantage of keeping the moulds clean and drying them uniformly, while in addition the use of what would otherwise be waste gases is a source of fuel economy.

When blast-furnace gas was first adopted for drying purposes, there occurred several cases of poisoning. The refined gas has a more narcotising influence than the unrefined gas, and apart from this it has no smell,

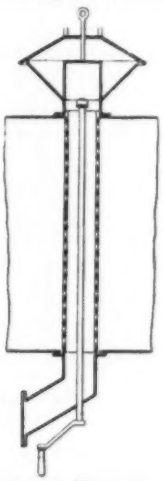


FIG. 1.—CHARGING FUNNEL AND SHAKING APPARATUS FOR CALCIUM CARBIDE.

for which reasons its presence cannot be discovered before its poisonous nature has had time to be effective. In regular work it is impossible to altogether prevent leakages from the pipes, etc., and it therefore has been found necessary to mix the gas with something that will give it a peculiar smell which will be easily recognisable. Experiments with this object in view have resulted in the adoption of calcium-carbide for the purpose. Calcium-carbide in pieces about ¾ in. to 1 in. in size, is placed in the pipes in a net-work basket. The gas, passing through the pipes, envelopes the calcium-carbide, which absorbs the moisture from the gas, thus generating acetylene gas. The acetylene then mixes with the other gas and imparts to the latter its penetrative odour. This process increases the heating value of the gas to some extent and reduces the content of water. The cost is only trifling.

The calcium-carbide as it decomposes through contact with the moisture, forms oxide of calcium: and in order to prevent the latter from encrusting the net-work basket, and thereby preventing the admission of the gas to the calcium-carbide, a shaking apparatus for the removal of the oxide of calcium has been arranged. Fig. 1 shows a style of grate-basket for the calcium-carbide, supplied with a charging-funnel and shaking apparatus. The charging-funnel is air-tight and made

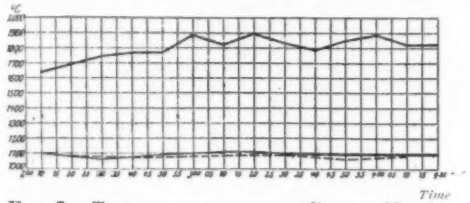


FIG. 2.—TEMPERATURES DURING CHARGE No. 1.

——— = Furnace
——— = Products of Combustion } in Regenerator Chambers.
..... = Heating Gases

sufficiently large to hold a supply of the material for several weeks. After each shaking for the removal of the oxide of calcium the basket is refilled automatically from the charging-funnel.

In pipe foundries blast-furnace gas is chiefly utilised for the drying of moulds and heating of drying ovens.

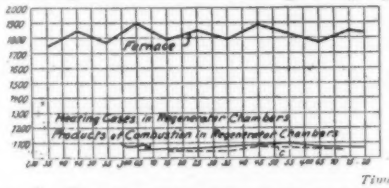



FIG. 3.—TEMPERATURES DURING CHARGE No. 2.

For the drying of pipe-moulds, the diameter largely governs the choice of the burner. For narrow moulds a weak, but long-shaped flame can be used with the greatest advantage. For moulds of large diameter a burner is required which produces a broader flame. When pipe-moulds of a diameter up to 12 in. are placed on rotating-tables, it is possible to use fixed burners, which are arranged underneath the tables. On the distributing gas pipe are a number of small pipes with burners attached, which can be easily placed under the different moulds. For the heating of drying-ovens for pipe-moulds the gas supply pipes are placed along the floor in the oven and the burners are attached to these.

In pipe foundries and steel foundries the moulds are dried either by hanging a burner in the upright mould

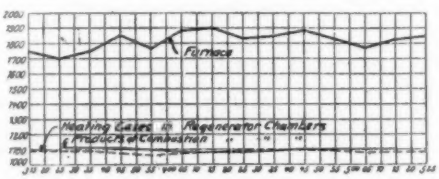



FIG. 4.—TEMPERATURES DURING CHARGE No. 3.

or by placing the mould over the burner, allowing sufficient space for the admission of air for combustion.

Large drying ovens are heated by attaching burners to a supply pipe arranged along the walls a short distance from the floor. This allows room in the ovens for the core wagons, which run on the ground, and on

* Abstract of article by R. Busk in "Stahl und Eisen."

which the cores are placed for drying. By means of this arrangement a sufficiently high temperature is obtained during the night to properly dry the cores, which are placed in the oven during the day. The same arrangement has also proved serviceable in

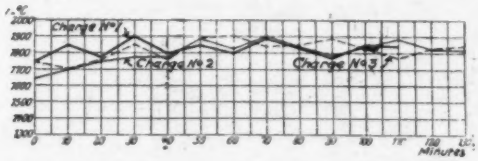



FIG. 5.—COMPARISON OF FURNACE TEMPERATURES; CHARGES NOS. 1, 2, AND 3.

the drying of loam moulds. The drying-chambers must during the daytime be used as mould-ing shops in order to avoid moving the heavy moulds. In the evening the doors and windows of the rooms are shut and the burners are lighted. Two or three hours before work is to be commenced the next morning the doors and windows are opened again.

Large moulds, such as for gas-engine cylinders, are

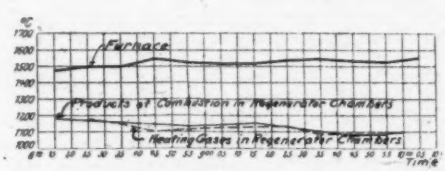



FIG. 6.—TEMPERATURES DURING CHARGE NO. 4.

dried by placing the burner in the mould's interior. For the drying of cores, etc., small drying-ovens are used which are heated by means of single burners and may be placed anywhere, preferably in the vicinity of the core benches.

### Blast-Furnace Gas for Heating Open-Hearth Furnaces.

Producer gas has up to the present been employed for the heating of open-hearth furnaces, but is now being gradually superseded by coke-oven gas, or rather by a combination of blast-furnace gas and coke-oven gas. In order to obtain the high temperature required for the melting of steel the various gases are mixed in proportions that give a gas with a heating value of from 6,400 to 7,500 B.T.U. Experiments carried out at the Friedrich-Wilhelmshütte at Mühlheim-Ruhr have shown that it is quite possible to use blast-furnace gas alone, but the process requires considerably more time and would probably affect the quality of the steel. The coke-oven gas and the blast-furnace gas are generally mixed in the proportion of 1 to 4, the mixing taking place before the gases enter the distributing valve.

TABLE I.

| Charge number. | Time of observation. | Temperature deg. Centigrade. Open-hearth furnaces. | Regenerator chambers for— Heating gas | Regenerator chambers for— Products of combustion. | Gas employed. |
|---|---|---|---|---|---|
| 1 | h. m. | | | | Mixture of coke-oven and blast-furnace gases. |
| | 2 35 | 1,744 | — | — | |
| | 2 45 | 1,848 | — | — | |
| | 2 55 | 1,770 | — | — | |
| | 3 5 | 1,900 | 1,060 | — | |
| | 3 15 | 1,756 | 1,060 | 1,050 | |
| | 3 25 | 1,848 | 1,070 | | |
| | 3 35 | 1,796 | — | 1,050 | |
| | 3 45 | 1,887 | 1,080 | 1,085 | |
| | 3 55 | 1,822 | 1,100 | | |
| | 4 5 | 1,770 | 1,085 | — | |
| | 4 15 | 1,848 | 1,085 | 1,060 | |
| | 4 20 | 1,836 | 1,070 | — | |
| 2 | 2 10 | 1,640 | 1,100 | — | do. do. |
| | 2 20 | 1,692 | — | 1,080 | |
| | 2 30 | 1,744 | 1,060 | — | |
| | 2 40 | 1,770 | — | 1,070 | |
| | 2 50 | 1,770 | 1,090 | — | |
| | 3 0 | 1,887 | 1,100 | — | |
| | 3 10 | 1,822 | 1,110 | — | |
| | 3 20 | 1,900 | 1,110 | — | |
| | 3 30 | 1,836 | — | 1,090 | |
| | 3 40 | 1,796 | 1,090 | — | |
| | 3 50 | 1,848 | — | 1,060 | |
| | 4 0 | 1,887 | 1,090 | — | |
| | 4 10 | 1,822 | — | 1,080 | |
| | 4 20 | 1,822 | 1,090 | — | |

| Charge number. | Time of observation. | Temperature deg. Centigrade. Open-hearth furnaces. | Regenerator chambers for— Heating gas. | Regenerator chambers for— Products of combustion. | Gas employed. |
|---|---|---|---|---|---|
| 3 | h. m. | | | | Mixture of coke-oven and blast-furnace gases. |
| | 3 15 | 1,744 | — | 1,090 | |
| | 3 25 | 1,692 | 1,110 | — | |
| | 3 35 | 1,744 | — | 1,090 | |
| | 3 45 | 1,848 | 1,110 | — | |
| | 3 55 | 1,770 | — | 1,060 | |
| | 4 5 | 1,887 | 1,080 | — | |
| | 4 15 | 1,900 | — | 1,080 | |
| | 4 25 | 1,836 | 1,080 | — | |
| | 4 35 | 1,848 | — | 1,100 | |
| | 4 45 | 1,887 | 1,100 | — | |
| | 4 55 | 1,822 | — | 1,090 | |
| | 5 5 | 1,770 | 1,100 | — | |
| | 5 15 | 1,722 | — | 1,080 | |
| | 5 25 | 1,848 | 1,080 | — | |
| 4* | 8 15 | 1,478 | 1,180 | — | Blast-furnace gas. |
| | 8 25 | 1,494 | — | 1,180 | |
| | 8 35 | 1,494 | 1,130 | — | |
| | 8 45 | 1,549 | — | 1,100 | |
| | 8 55 | 1,523 | 1,130 | — | |
| | 9 5 | 1,517 | — | 1,130 | |
| | 9 15 | 1,517 | 1,150 | — | |
| | 9 25 | 1,536 | — | 1,130 | |
| | 9 35 | 1,542 | — | 1,085 | |
| | 9 45 | 1,530 | 1,075 | — | |
| | 9 55 | 1,525 | — | 1,080 | |
| | 10 5 | 1,550 | 1,100 | — | |

| Charge number. | Time of observation. | Temperature deg. Centigrade. Open-hearth furnaces. | Regenerator chambers for— Heating gas. | Regenerator chambers for— Products of combustion. | Gas employed. |
|---|---|---|---|---|---|
| 5† | h. m. | | | | Mixture of coke-oven and blast-furnace gases. |
| | 5 5 | 1,523 | 1,120 | — | |
| | 5 15 | 1,494 | — | 1,110 | |
| | 5 25 | 1,517 | 1,120 | — | |
| | 5 35 | 1,530 | 1,130 | — | |
| | 5 45 | 1,640 | — | 1,100 | |
| | 5 55 | 1,549 | 1,110 | — | |
| | 6 5 | 1,530 | — | 1,100 | |
| | 6 15 | 1 640 | 1,110 | — | |
| | 6 25 | 1,640 | — | 1,100 | |
| 6‡ | 5 30 | 1,549 | — | 1,100 | do. do. |
| | 5 40 | 1,501 | — | 1,110 | |
| | 5 50 | 1,692 | 1,100 | — | |
| | 6 0 | 1,640 | — | 1,090 | |
| | 6 10 | 1,822 | 1,100 | — | |
| | 6 20 | 1,900 | — | 1,090 | |

* Charge not finished.
† Experiment discontinued owing to necessity of changing the proportions of gases used in mixture.
‡ Charge finished.

During a period of two years and a half this combination of gases has been employed at the Friedrich-Wilhelmshütte, with very good results, for two acid open-hearth furnaces of 12 tons and 15 tons capacity respectively. At these works the blast-furnace gas passes through a 23½ in. pipe in a rather elevated position. The coke-oven gas, however, passes through a 10 in. pipe underground. The arrangement of the furnace as regards blast, regenerators, etc., is the same as when producer gas is employed. Some results from the working of experimental charges are shown in Tables I., II. and III., and graphically in Figs. 2 to 9, The furnace was heated with the mixed gases, except in only one case, where blast-furnace gas alone was employed.

It will be seen that with a mixed gas with a heating value of 6,400 to 7,600 B.T.U. the temperature of the furnace varied from 1,700 to 1,900 deg. Centigrade, according to the proportions of air and gas and

the prevailing pressure of the mixed gas. It was impossible to determine the exact proportions of air and gas, but on analysis no excess air could be discovered.

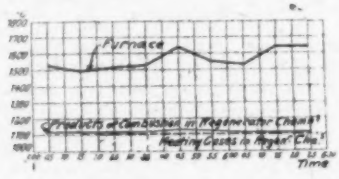



FIG. 7.—TEMPERATURES DURING CHARGE NO. 5.

The coke-oven gas and blast-furnace gas were mixed in proportions varying from 1—3 to 1—6.5, which corresponds to respectively 8,000 and 6,000 B.T.U., and to an average temperature of the furnace of respectively 1,800 and 1,500 deg. Centigrade.

TABLE II.—*Chemical Composition of the Heating Gas and Products of Combustion.*

| Charge No. | Gas Employed. | Proportion of Coke-oven Gas to Blast-furnace Gas. | Analysis. Per cent. $CO_2$ | CO | O | $H_2$ | $CH_4$ | Average heating value of gas in B.T.U. |
|---|---|---|---|---|---|---|---|---|
| | Mixture of coke-oven and blast-furnace gases | 1 to 4 | 5.4 | 18.0 | 0.2 | 28.5 | 5.1 | 7,600 |
| 1 | Products of combustion— | | | | | | | |
| | In regenerator chambers ... | — | 6.1 | 2.3 | 0.5 | 3.4 | — | — |
| | In stack ... | — | 5.6 | 1.0 | 11.2 | — | — | — |
| | Mixture of coke-oven and blast-furnace gases | 1 to 4.5 | 4.2 | 16.0 | 0.8 | 29.0 | 3.0 | 6,650 |
| 2 | Products of combustion— | | | | | | | |
| | In regenerator chambers ... | — | 5.1 | 2.6 | 0.4 | 4.1 | — | — |
| | In stack ... | — | 6.8 | 0.6 | 10.0 | — | — | — |
| | Mixture of coke-oven and blast-furnace gases | 1 to 4 | 4.4 | 15.0 | 0.6 | 36.7 | 4.2 | 7,100 |
| 3 | Products of combustion— | | | | | | | |
| | In regenerator chambers ... | — | 6.0 | 3.2 | — | 5.9 | — | — |
| | In stack ... | — | 5.6 | 1.0 | 10.2 | — | — | — |
| | Blast-furnace gas ... ... | — | 8.8 | 31.0 | 0.2 | 2.1 | — | 4,000 |
| 4 | Products of combustion— | | | | | | | |
| | In regenerator chambers ... | — | 9.2 | 4.8 | 0.5 | — | — | — |
| | In stack ... | — | 10.2 | 1.6 | 10.4 | — | — | — |
| | Mixture of coke-oven and blast-furnace gases | 1 to 6.5 | 5.8 | 19.2 | 0.6 | 21.2 | 2.3 | 5,800 |
| 5 | Products of combustion— | | | | | | | |
| | In regenerator chambers ... | — | 6.4 | 2.2 | 0.2 | 1.8 | — | — |
| | In stack ... | — | 5.8 | — | 12.0 | — | — | — |
| | Mixture of coke-oven and blast-furnace gases | 1 to 3.0 | 3.0 | 11.2 | 0.2 | 38.2 | 5.5 | 8,000 |
| 6 | Products of combustion— | | | | | | | |
| | In regenerator chambers ... | — | 5.2 | 2.2 | 0.4 | 4.8 | — | — |
| | In stack ... | — | 2.4 | 0.4 | 13.2 | — | — | — |

Charges Nos. 1 to 3 were steel charges, the observations covering the whole of the heat. Charges Nos. 4 to 6 were only experimental charges, in the first of which blast-furnace gas alone was employed, while the

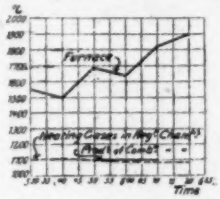



FIG. 8.—TEMPERATURES DURING CHARGE NO. 6.

ratio between the component gases was altogether different in the two last charges. Tables I. to III. and the diagrams 6 to 9 show the various temperatures of the furnace as well as the analyses of the heating gas and of the products of combustion.

The reading of the temperature in the furnace was commenced as soon as the charge had been melted,

TABLE III.—*Chemical Composition of the Steel Produced.*

| Charge No. | Heating Gas employed. | Analysis. Per cent. C. | Si. | Mn. | S. | P. |
|---|---|---|---|---|---|---|
| 1 | Mixture of Coke-oven and Blast-furnace gas. | 0.224 | 0.18 | 0.52 | 0.049 | 0.062 |
| 2 | | 0.234 | 0.17 | 0.57 | 0.051 | 0.063 |
| 3 | | 0.280 | 0.18 | 0.49 | 0.053 | 0.067 |

and after this it was continued with intervals of 10 minutes until tapping or the conclusion of the experiment. The temperature observations were made through a hole in the centre of the furnace by means of a Wanner pyrometer placed at a distance of about 8 ft. from the hole. The temperatures of the heating gas and of the products of combustion were ascertained by a means of a Le Chatelier pyrometer. The apparatus extended about two feet into the regenerator chamber,

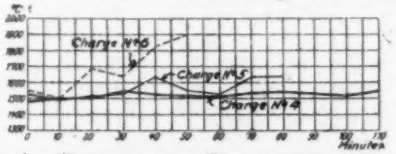



FIG. 9.—COMPARISON OF FURNACE TEMPERATURES; CHARGES NOS. 4, 5, AND 6.

and the opening around it was filled up with clay to exclude cold air. The temperature of the heating gas and of the products of combustion varied from 1,050 to 1,150 deg. Centigrade. The temperature of the heating gas was, however, lower in general than that of the products of combustion.

The gas samples were taken about half-way through the experiments, and the analyses were made by means of the Orsat apparatus. The samples of heating gas were taken just outside the distribution valve, where it was concluded that a complete combination of the gases had taken place. The samples of the products of combustion were taken partly through the peep-hole of the right chamber and partly through an opening in the chimney just above the ground.

For annealing ovens in steel foundries blast-furnace gas might also be employed. In such cases it is advisable to so arrange the ovens that the blast-furnace gas mixed with coke-oven gas, or alternatively producer gas can be employed as desired.

# The Solidification of an Iron Casting in the Mould.

By Professor Thomas Turner, M.Sc.

Before the London Branch of the British Foundrymen's Association on December 8 last, an interesting lecture was delivered by Professor Thomas Turner, of the University, Birmingham, on "The Solidification of an Iron Casting in the Mould." Mr. J. Oswald, Branch-President, occupied the chair, and there was a large attendance of members and visitors, including a number of engineering students, for whom the lectures at this Branch are particularly well designed.

The lecturer opened by recalling the fact that iron when cast in a mould exhibited shrinkage from the size of the mould, this shrinkage varying according to the quality of the iron and the shape of the casting, but being generally about 0.125 in. per foot with ordinary foundry mixtures. A white iron displayed the greatest shrinkage, and as the grade approached that of a medium iron, say No. 3, the shrinkage was less, while an open grade, say a No. 1, gave a casting more nearly the size of the mould. This feature of shrinkage, which involved "drawing" between different parts of a casting, gave strain troubles with casting which embodied considerable differences in thickness. Before going further, the lecturer proceeded to define the terms shrinkage and solidification, in order to obviate much of the misunderstanding which surrounded the subject. Shrinkage was the difference between the size of the casting when cold and the mould in which it was cast—or between pattern and casting. He ignored the definition sometimes put forward associating shrinkage with the molten metal and contraction with the solid casting. As regards the term "Solidification," this to the physical chemist implied that process whereby the crystals gave out their latent heat of fusion; hence glass, for example, was not regarded as a solid but as a super-cooled liquid. But this distinction was not necessary for practical work; solidification might be taken to include all that occurred from the moment the fluid metal was poured until the resulting casting was fit for removal from the mould.

On the measurement of shrinkage Keep's shrinkage test was described and illustrated, this being a simple and useful test for application in the foundry. The next point brought out was as to the expansions in irons during solidification. That actual expansions did occur at certain intermediate points, despite the ultimate contraction, was shown by the experiments of the elder Mallet with a spherical casting, which experiments indicated that a phosphoric iron displayed three distinct expansions during cooling. These were not uniform, though they took place at definite temperatures and in regular order, at points above red heat. The significance of these expansions was explained by the lecturer in connection with cooling curves of steel and irons. These curves showed definite recalescence points which indicated heat generated by the separation out of solution of carbon, and in the case of a phosphoric iron, of the phosphorus eutectic at one point. In a non-phosphoric iron there were only two arrest points in the cooling curve, both of which were associated with the carbon. At the first arrest large or primary graphite separated out and at the second fine or secondary graphite was thrown out of solution. The lecturer here described and illustrated his own and Wüst's methods of measuring shrinkage.

Dealing with the equilibrium diagram, Professor Turner described it as the "Bradshaw" of the series of alloys to which it related. He briefly explained its application, and in passing, deprecated the avoidance of its use for which most foundrymen were noted. With regard to the Phase Rule, this was often referred to as too abstruse for the foundryman's comprehension, but it was really extremely simple. It stated that with a falling temperature only one constituent of an alloy could crystallise out at a time; but at a point where the temperature remained constant for a while, as at the eutectic temperature, two constituents might separate out together.

Coming to the crystallisation of iron, the lecturer showed a number of photomicrographs illustrating the structure formed by the separation of different constituents, and explained how the dendritic structure of iron crystallisation was formed, enclosing areas of eutectic. The formation of graphite at the first change in cooling was illustrated, and another slide showed specimens of large graphite and temper carbon deposited from a solution which had been poured on to the glass of the slide. The large graphite separated out at the first expansion after solidification; after cooling another 200 degrees a second expansion took place, during which the phosphorus separated out, often forming hard nodules. At the third change, about another 200 degrees lower, pearlite tended to form, and this in the presence of much silicon decomposed and fine graphite was formed. Below that point the cooling was regular, no temperature arrests or expansions being displayed.

In conclusion, the lecturer pointed out how the facts enunciated might be applied with advantage in the foundry in connection with the cooling of different irons. It was necessary to avoid, if possible, all sharp alterations of form in the design of a casting, and also great variations in thickness, as these would necessarily cause shrinkage strains and weaknesses in the casting. Where such alterations were unavoidable it was necessary to employ an iron which had little expansion, *i.e.*, an iron not very phosphoric and not too open in the grain.

### Discussion.

THE CHAIRMAN, in thanking the lecturer for his excellent address, referred to his researches in the metallurgical field, remarking that he was recognised as a first authority on the effect of silicon on the iron alloys.

MR. BREARLEY desired to know why graphite was sometimes found in the metal in the form of streaks and sometimes in the form of globules. The lecturer, in reply, questioned whether it actually did occur in cast iron as globules, or whether the globules referred to were not of some other composition, such as phosphide or sulphide, which often had the appearance of graphite.

MR. MILTON mentioned the case of a casting for a Parsons' turbine, which was specified to be annealed, and asked whether anything could be done in that way to relieve the strains set up in an iron casting, as in steel castings.

MR. BENNETT asked the lecturer what he considered a suitable mixture for general foundry use? Also, should castings be left in the mould as long as possible or removed as soon as solid?

Mr. Nash wished to know whether the lecturer considered durability a function of hardness? He also believed that liquid expansion took place before the metal solidified, apart from the expansions mentioned by the lecturer.

Mr. Hamilton remarked that in engineering work he was at present working on a safety factor of 10; but he considered that the application of scientific methods to founding should allow this factor to be reduced by 50 per cent. He elicited from the lecturer the information that white iron did show an expansion during cooling, but only a small one; and that the maximum strength so far obtained from cast-iron was 22½ tons.

Mr. Bartlett recalled that phosphorus was stated by one writer to help iron to solidify quicker. Would the lecturer recommend high or low phosphorus for rapid machining and close grain?

Mr. J. Horne said that the diagrams exhibited showed that an iron with low phosphorus had only one expansion, while a Northampton (high phosphorus) iron had three. Was it advisable to reduce the phosphorus to get less chance of fracture?

A Visitor desired to know why the skin on a large grey-iron casting during machining would sometimes be so soft and ductile as to curl up under the tool like a mild steel.

Professor Turner, in reply, said that in large castings some strains could not be avoided. They could be rendered small, however, by using an iron which was not too hard, and by avoiding sharp edges and corners in the design. In special cases it was sometimes an advantage to anneal the casting; but too frequent annealing of a grey iron would make it grow. In reply to Mr. Bennett, there was no bad and no good foundry mixture; the value depended on the work for which it was used. But for general foundry work a suitable mixture was one having the following composition: G.C., 2.7 per cent.; C.C., 0.35 per cent.; Si., 1.5 per cent.; P., 0.7 per cent.; S., 0.08 per cent.; Mn., 0.5 to 0.6 or 0.7 per cent. A reduction of the silicon would give a harder iron and an increase a softer. As to the leaving of castings in the mould, in some cases this should not be done, or they would crack, as occurred with chills used in the cast-iron bedstead trade. But for ordinary castings it was advisable to leave them in the mould, as they would tend to anneal themselves through the retention of the heat. The use of a medium-character iron would avoid cracks. Regarding durability and hardness, these did not always go together. With a heavy weight and a slow speed they might not do so, as the result of the graphite rubbing out and forming a lubricating skin between the rubbing surfaces. A practical test, however, was the only way to ascertain durability, which quality varied according to the weight and speed. He had so far made no tests regarding liquid expansion, though some were at present being conducted by Mr. Hailstone. The phenomenon mentioned by some speakers, *i.e.*, swelling of the metal in the riser or git, did not prove anything, as that might result from the expansion of a solid shell of metal in the mould pushing up the molten metal in the riser. Regarding a question as to heat treatment for enabling castings to resist pressure, small graphite was the essential for pressure resistance; heat treatment of a casting with an open structure would not do so, since it would allow the graphite to become dissolved in the carbon, but would leave a porous structure in place of the graphite. For rapid machining, 1.5 per cent. of phosphorus was suitable; over that amount made the castings hard. This would do for common materials, but if a strong iron were desired this was too much phosphorus, as the castings were very apt to fracture. To reduce the phosphorus was to get a tougher casting. He suggested as an explanation of the tough, ductile skin on the heavy casting mentioned, that the surface metal had become decarbonised by contact with the atmosphere.

## British Foundrymen's Association.

### London Branch.

On December 9th last, the first annual dinner of the London Branch of the British Foundrymen's Association was held at Holborn Restaurant, W.C. The function was attended by over 80 members and visitors, and was acknowledged to have been a striking success. An excellent programme of music was arranged, interspersed by a few toasts.

Mr. J. Horne (Vice-President of the Branch), in proposing "Kindred Societies," remarked that in recent years the various societies which were associated with the foundry and metallurgical industries had extended their influence to raising the standard of young men who were to be captains of industry. The pioneers in this were the Institution of Civil Engineers and the Institution of Chemical Industry. In the line of industrial research the Mechanical Engineers and the Iron and Steel Institute were prominent, while the Institute of Metals, too, was emulating the example of the older societies. These were the right lines to work upon if we were to remain in the leading ranks among the nations.

Professor Thomas Turner (Birmingham University), in replying, remarked that all these societies had a number of things in common. The organisation of industries was necessary to maintain advancement, and while the Guilds in the past had done that work, the modification of trades had rendered their work unnecessary. The period which followed the lapse of the Guilds' work was one of unorganised conditions, to the disadvantage of the crafts. The rise of the technical societies, however, had largely met the want, and it should now be their object to give the workers new ideals, and a sense of the honour and dignity attached to their craft. In conclusion, he suggested that London was destined to be the centre of the British Foundrymen's Association, but that would largely depend on the development of the local branch.

Mr. Holloway, in proposing the toast of "The British Foundrymen's Association," remarked that foundrymen's societies originated with Tubal Cain—all the existing societies were really branches of that old parent. The success which the Institute of Metals had recorded in the non-ferrous trades should be an additional stimulus to the British Foundrymen's Association, and encourage them to look forward to a great future.

Mr. Ellis (Member of the General Council) responded for the Association, remarking that when he recalled the inception of the organisation, he remembered that of 100 invitations sent out, only five attendances were recorded on the first night. He confirmed Professor Turner's suggestion that London would be the future headquarters of the Association; this was the hope of the Council. London might not be a centre of foundry work, but the engineering trade societies had found it the best place to establish themselves, and it would be the best for the British Foundrymen's Association.

Mr. A. Mappin has been the recipient of a presentation in recognition of the completion of twenty years' service as head warehouseman at the Wallace Steel Works, Sheffield, of Messrs. A. Blyde & Company. Mr. J. E. A. Blyde made the presentation at the annual gathering of workmen prior to the holiday.

# Tropenas Converter Plant.

Descriptions have recently been published* of the Tropenas converter steel foundry of the Bayonne Steel Casting Company, Bayonne, N.J., U.S.A., from which we take the following particulars and illustrations:—

### Tropenas Plant of the Bayonne Steel Casting Company.

In this foundry, the raw materials enter at the back and travel forward continuously until they leave the shipping room as the finished product. Machinery is used wherever possible to avoid the laborious and expensive hand methods. Ore, coke, scrap, pig-iron, etc., are brought into the foundry yard on a branch track from the railroad and unloaded directly from the cars into their respective storage spaces. Above the latter is an overhead track, carrying a small electric trolley hoist arrangement, so that sheet-steel buckets loaded with the raw materials can be picked up, carried into the foundry and dumped on the charging floor, or into a chute which discharges them into the cupola.

Fig. 2 is a view of the charging floor, with raw materials for a complete cupola charge piled upon it, and shows more plainly the trolley hoist. The rail is directly in line with the centre of the cupola, and the wooden tray, hanging from the hoist, is open at one end, so that it can be discharged by tilting it until the load slides into a chute (not shown) and thence into the cupola.

The melted metal is drawn from the cupola spout, Fig. 3, into large steel-plate ladles handled by the overhead travelling crane and poured into the Tropenas converters on either side of the cupola. The converters discharge into ladles placed in the pits in front of them. The metal is transferred into smaller ladles, and from these to the moulds. At the extreme right of Fig. 3 is a small cupola that is used for melting down the alloys. The cupola and the converters are in a corner of the main foundry just back of the columns supporting the roof trusses and the travelling crane track. The ladles of molten metal can thus be easily handled by the overhead cranes and the hot metal is readily accessible for the moulders.

At one end of the main building are the sand bins and sand mixing machinery. At the right of Fig. 6 is shown the moulding sand crusher or grinding pan. The machine at the left mixes the sand either for core making or moulding. The sand is shovelled into the hopper, where the coarsest foreign substances are removed, and is then picked up by buckets, and carried to the top where it is dumped on a vibrating screen or riddle and passes through several other operations. Behind this machine and occupying this entire corner of the foundry are the large sand bins which are filled directly from railroad wagons run in on the sliding just outside the building. After being prepared in the machine the sand is put into

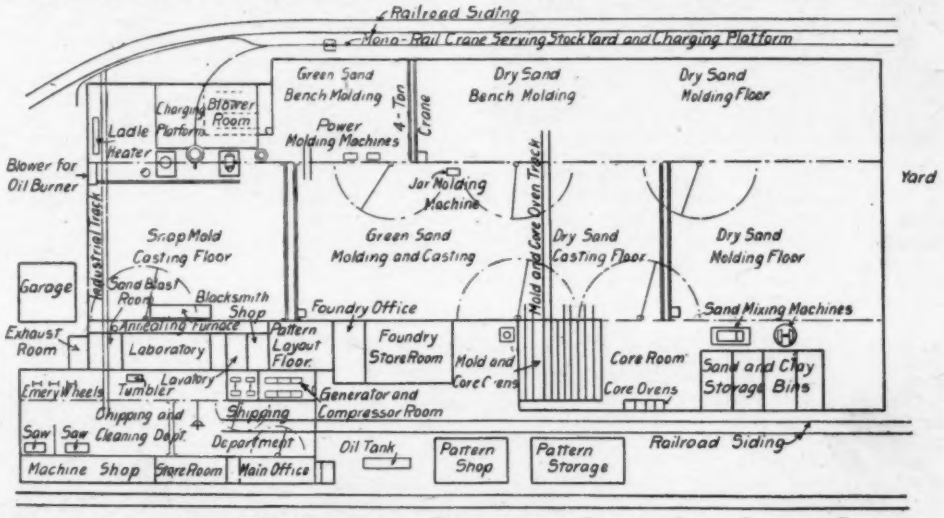



FIG. 1.—PLAN SHOWING ARRANGEMENT OF PLANT OF THE BAYONNE STEEL CASTINGS COMPANY.

huge buckets and transferred to the moulding floor by the overhead crane.

Numerous jib cranes are used throughout the foundry. These are detachable and portable and are secured to the building columns by hinges that allow them to be lifted and transferred from one column to another by the overhead travelling crane. A jib crane is provided for every three or four columns, and each has an air hoist mounted on four wheels, and travelling on the I beam forming the radial arm of the crane. This arm swings through a semi-circle and the crane can thus cover a large amount of floor space.

While the drying ovens are of the ordinary type, with roll-top doors, the mould cars, as shown in Fig. 5 have some points of special interest. The platform of the car is built of I-beams and channel irons, and on the centre line are securely fastened two uprights, each containing two rows of staggered holes, in any of which arms (A, Fig. 5) can be placed. On these arms shelves are placed to receive the moulds to be dried. These shelves are distributed among the moulders making dry-sand moulds and the finished moulds are placed on them on the moulders' floor. When a shelf is filled the crane picks it up and carries it to the drying-oven car. As soon as the floor of the car is filled arms are placed in holes in the uprights so

* "Iron Age." and "Iron Trade Review."

they will just clear the moulds beneath and the first shelf is put in position, and so on until the top is reached. This arrangement allows moulds to be stacked up on the cars to the full height of the oven and without waste space, due to various heights of moulds. It also allows the hot air to circulate freely over the top of the moulds as well as on all sides and

FIG. 2.—CHARGING FLOOR; SHOWING CUPOLA BEING CHARGED FROM CAR.

thus dry them quickly. The ease with which the moulds can be handled is also conspicuous. When a carload of dried moulds has been rolled out of the oven the travelling crane successively removes the shelves and distributes them about the floor.

rope is run through this pulley and fastened to the car, and the other end is given a turn around the hook of the travelling crane. A man on the floor then retains the free end of the rope while the crane

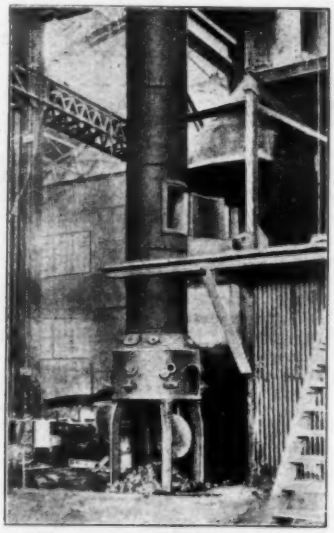


FIG. 4.—SMALL CUPOLA FOR MELTING FERRO-ALLOYS.

hoists and pulls the car out of the oven. Similarly with loops and pulleys at the inner ends of the oven tracks, the cars can be pulled into the oven.

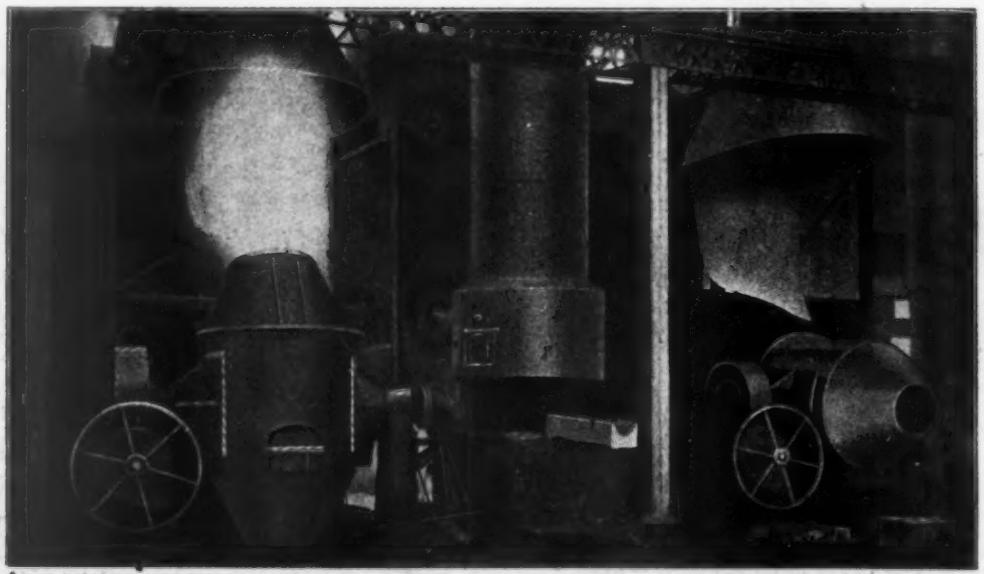


FIG. 3.—CONVERTER PLANT AT FOUNDRY OF BAYONNE STEEL CASTINGS; ONE CONVERTER IN OPERATION AND THE OTHER TURNED DOWN FOR REPAIRS.

Considerable manual labour is also saved in running the cars into and out of the ovens. Two drying ovens are now in use with two tracks and two doors to each oven, and in front of each track a loop of wire rope is anchored in the floor to take the hook of a pulley such as that shown in Fig. 5. One end of the wire

### The Finished Castings.

After the castings are shaken out of the moulds, they are picked up by overhead travelling cranes and carried to the end of the foundry near the converters and loaded on narrow-gauge flat cars. These take them through a sand-blast room, where they can be

sand blasted if necessary, and then into the cleaning rooms.

The plant has been so designed that the sand is brought into one corner of the building where it is ground and mixed and then deli-

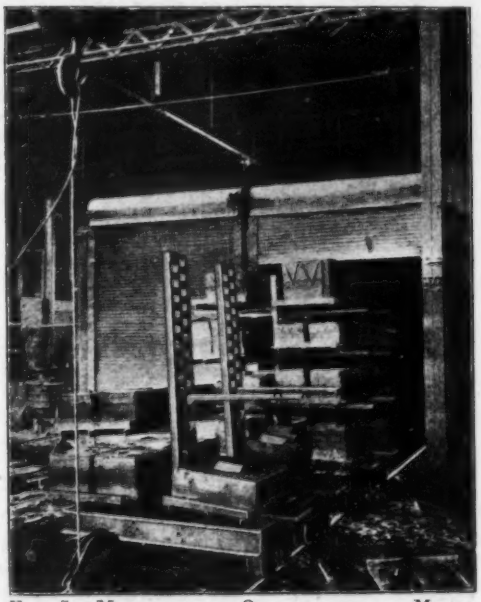


FIG. 5.—MOULD-DRYING OVENS; SHOWING MOULD CARS.

vered to the moulders and core-makers; the pig-iron, ore, coke, scrap, etc., are brought into the diagonally opposite corner, where they are charged into the cupolas and converters and made into steel; the molten metal is distributed over the moulding floor and poured into the moulds, the castings are shaken out, taken to the annealing ovens and from there to the cleaning room, through which they pass and are halted for various operations before being loaded for shipment.

## A NEW COPPER ALLOY.

According to "La Fonderie Moderne," a new copper alloy of high tensile strength and great hardness has been invented by a French metallurgist. For the manufacture of the alloy 11 lbs. of chromium are melted for one hour with 11 lbs. of aluminium,

FIG. 7.—JIB-CRANE EQUIPPED WITH AIR HOIST.

and then 242 lbs. of copper are added. The entire charge is kept at fusing temperature during one-half hour. Then 55 lbs. of nickel are added and the mixture is heated another hour, upon which 44 lbs. of zinc are added. The proportions of copper and chromium can be varied according to the use to which the alloy is to be put, but the additions of aluminium and the order in which the metals are brought to melting temperature must not be changed.

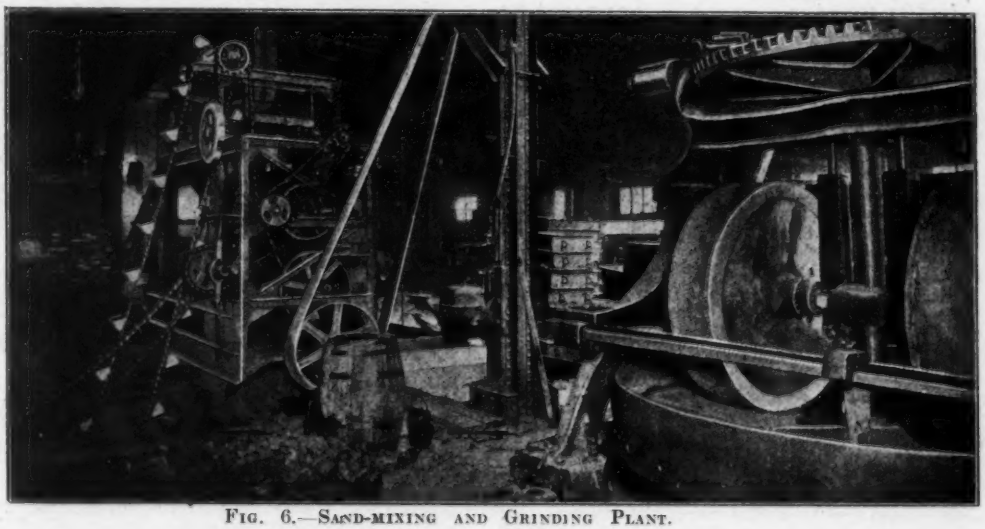


FIG. 6.—SAND-MIXING AND GRINDING PLANT.

# The Helberger Electric Furnace.

The advent of the electric furnace has resulted in the fact that not only has electricity been largely adopted in connection with ferrous metals (iron and steel and their alloys with other minerals), but it has also come into vogue for melting metals such as tin, zinc, lead, brass, copper, nickel, silver, gold, and even platinum. In this connection some interesting work has been done with an electric transformer crucible furnace produced under the patents of Mr. Hugo Helberger, of Munich, which has been used not

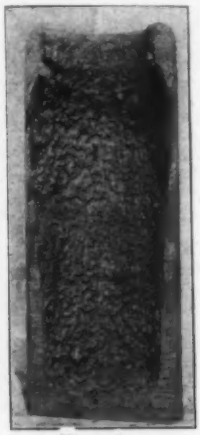


Fig. 1.

only for the purposes enumerated above, but also for melting glass and enamels. The melting takes place in ordinary graphite or charcoal melting crucibles which are prepared by a special process, and one of which is shown in section in Fig. 1 after having been used in the Helberger furnace for melting copper. The furnace comprises (1) a transformer wound for any suitable voltage of supply, and (2) water-cooled holding mechanism for the crucible, directly connected to the transformer and provided with carbon contacts. The transformer and furnace thus produce a combined piece of apparatus, its appearance for small capacities being shown in Fig. 2. An ampere meter and a regulating switch complete the equipment, the whole apparatus being self-contained, and in working order for connection with a system of alternating-current supply.

In operation the crucible is first placed within its holding mechanism and screwed down into position by means of the hand-wheel shown in Fig. 2. The container is then closed and a comparatively weak current (at first) is switched on. As the melting process develops the current may be strengthened through the medium of the switch as required. It should be noted that the holding-mechanism covers the crucible only on its edge, so that its contents can at all times be conveniently observed, and the opening thus afforded is also of advantage for charging the crucible and for stirring the contents. The exact moment can be noted when the melting is complete and additions can be put into the fused mass at the proper moment without disturbing the process. The bottom of the pedestal upon which the crucible stands is protected from deterioration by a water-cooling system. An advantage of the furnace is that the wide range of heat obtainable by the current regulation renders it adaptable either for dealing with very soft metals, such as lead or brass, or for hard material such as platinum or even quartz sand. In order to protect the crucible from undue deterioration, it is treated with a special composition before heating.

The type shown in Fig. 2 is adapted more especially for small melts and for laboratory work, and for these purposes it has been found to be most economical in practice. The larger-sized furnaces are provided with a tipping appliance as shown in Fig. 3, which is self-explanatory. By this means a considerable saving in time and therefore heat is

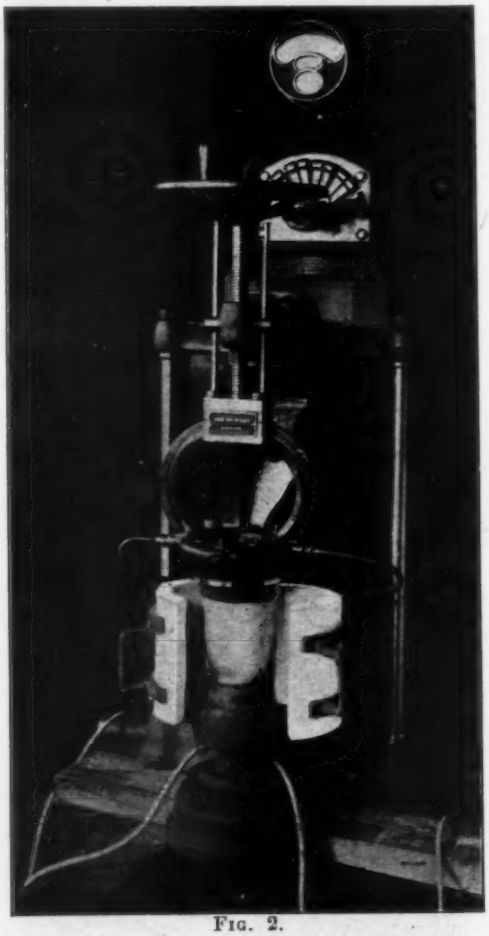


Fig. 2.

obtained, rendering it possible to obtain large melts and the maximum number of castings with a given expenditure of energy. Fig. 4 illustrates the pouring process in connection with a furnace of 100 kilogrammes (2 cwts.) capacity.

The transformers used are provided with twelve regulating points, the regulation being carried out by changing the winding relations of the primary and secondary coils, so that no loss of current results. The melting capacity of the furnace depends, of course, on the material operated upon. The furnace which will

deal with 6 lbs. of copper will only melt 2 lbs. of platinum, while a furnace to deal with 22 lbs.

FIG. 3.

of copper can only melt some 11 lbs. of iron. As a rough guide, it may be stated that 2 cwts. of iron

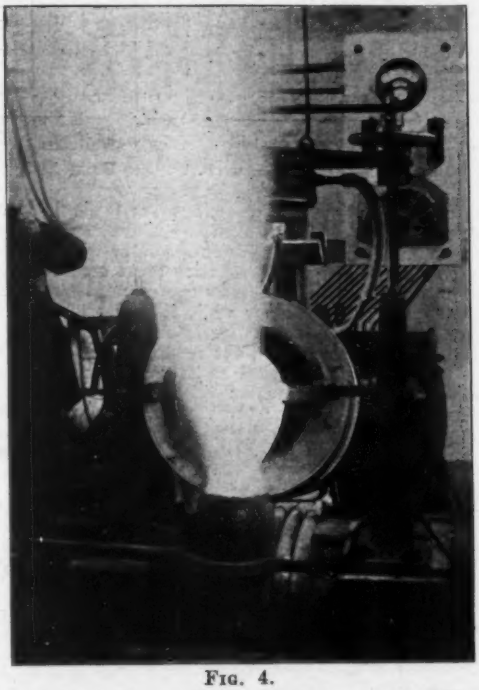


FIG. 4.

require 75 kw.-hours, 2 cwts. of copper require 37 kw.-hours, and 2¼ lbs. of platinum require 10 kw.-hours.

As regards working cost the following figures are furnished by the makers as a result of experiments on pure copper:—

| | | | |
|---|---|---|---|
| 36 lbs. | were melted in | 396 | kilowatt-minutes. |
| 40 ,, | ,, | 420 | ,, |
| 34 ,, | ,, | 376 | ,, |
| 44 ,, | ,, | 450 | ,, |
| 43 ,, | ,, | 408 | ,, |
| 44 ,, | ,, | 364 | ,, |
| 44 ,, | ,, | 408 | ,, |

A total of 285 lbs. of pure copper in 2,900 kilowatt-minutes.

Taking current at one penny per unit, the melting of 1 lb. of copper would therefore work out at 0.168d. As with private plants operated by producer or waste gas the cost of electricity per unit could be brought down to a much lower figure than a penny, the cost of melting would, of course, correspondingly diminish. The commercial value of the process is therefore evident.

## Electro-Magnets.*

BY E. C. IBBOTSON.

The principle of an electro-magnet is extremely simple, and consists of a coil of insulated wires wound round a core of iron. Whilst the current passes through the coil, a strong magnetic field is set up inside and outside the coil. The lines of force are, however, most powerful at each end of the core where the magnetisation is highly concentrated. On discontinuing the current, the magnetic field collapses, and the core is immediately de-magnetised. The latter possibility is also a valuable feature in the construction of electric lighting magnets, as it enables the electrical engineer to have the magnetism entirely under control. The strength of electro-magnets depends, to a certain extent, on the nature of the iron core.

Iron is magnetic; that is, it can be affected by a magnet below the critical temperature in the neighbourhood of 750 deg. C. It is therefore possible to handle hot rails, etc., under the temperature of about 750 deg. C., but the magnet should be properly designed for this work. Some special steels, such as manganese steels, and some high-nickel steels under certain conditions, are non-magnetic at the ordinary temperature.

The first horse-shoe type of electro-magnet, which is still used by some, is now being superseded by the pot magnet, of which the Witton-Kramer magnet is an example. These are manufactured by the General Electric Company, Limited, Birmingham. In the United States they make their magnets on truly American lines, namely, to work to their utmost limit of lifting capacity, without taking much care as to the heating effect of the current on the coil. The Witton-Kramer lifting magnet has a liberal rating for the coil, and the makers claim that the current can be left on for an hour without injuring it. The coil is mechanically protected by totally enclosing it in a solid steel shell of special high permeability steel; it is weather-proofed by vacuum drying and impregnating under pressure with hot bitumen. Direct current is used, and the consumption of current for large magnets, even where it has to be specially generated, is not a very serious cost. Generally, it will be readily appreciated that in many cases electro-magnets are a considerable labour-saving device.

* Abstract of Lecture delivered before the Sheffield Society of Engineers and Metallurgists.

# Alloys Used for Die-Castings.

In our issue of August last we reproduced from "The Iron Age" an article on "Die-Casting Machines," by E. F. Lake. The same author has now contributed to that Paper an article on the alloys used for die-castings, which we present herewith in abstract:—

As we may trace the origin of the die-casting principle back to the lead bullet mould that was a household utensil in the American Revolution, so we may also trace back to this period the metals or alloys that were used. Starting with the lead used in the manufacture of these bullets other metals were added to harden and strengthen it and give it better wearing qualities.

The printing press required a type of metal that would cast a sharp figure, withstand the necessary compression and be hard enough to wear well, but at the same time be cheap. To pure lead, therefore, tin and antimony were added, and this alloy was cast in metal moulds many decades ago. This made the first alloy that was cast in steel moulds for machine parts on a commercial scale. An ordinary type metal is made from 80 per cent. lead, 15 per cent. antimony and 5 per cent. tin. This also makes a good bearing metal, and Magnolia anti-friction alloy is of this composition.

There has been a vast improvement in the alloys that are made into die-castings. In ordinary practice we frequently meet with die-castings made from alloys whose ingredients may be any of the following metals: Zinc, tin, lead, copper, antimony, bismuth, aluminium, nickel, silver and iron. Iron, however, is nearly always an impurity, while nickel and silver are not used very often.

In these castings the zinc may vary anywhere from 93 to about 30 per cent.; the tin from 65 per cent. to zero; the lead from 93 per cent. down, and the antimony in percentages up to 26. In one instance, a copper content of 20 per cent. was used, but in most cases with a copper content of more than 10 per cent. it is difficult to cast the alloy, owing to its action on the moulds. In these alloys aluminium has been used in percentages as high as 6. The regular aluminium mixtures, however, have been successfully cast; that is, those that contain a high percentage of aluminium and a low percentage of zinc or copper, or both.

The accompanying table gives the composition of the alloys that are the most frequently met with in die-castings. The harder, tougher and stronger alloys and those having the best wearing properties comprise those with a zinc base. Where no special strength is required the lead-antimony-tin alloys, such as are used for various kinds of type and anti-friction metals, are often used for die-castings, as they are much cheaper.

While many good die-castings are being made, there are altogether too many produced that have a smooth outer surface while the metal is porous and spongy in the interior, and the casting is thus greatly weakened. Many others are made of metal mixtures that disintegrate and thus lose most of their strength in a short time. This is largely due to the fact that many persons engaged in the die-casting business who had a good mechanical knowledge and could design and manufacture machines, but who had very little practical information regarding metals and their actions when compounded into the alloys suitable for die-moulded castings. Some of these thought it only necessary to throw the metals into a melting pot, melt them down and stir them. Under such methods many poor compositions were made into die-castings that had a smooth outer surface, and as they looked good they were accepted, but soon failed in service. This gave the die-casting business a "black eye" in some places.

*Some Alloys used in Die-Moulded Castings.*

| Kind of alloy. | Zinc. | Tin. | Lead. | Copper. | Antimony. | Aluminium. |
|---|---|---|---|---|---|---|
| | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. | Per cent. |
| (a) | 92.6 | 3.5 | — | 2 | 1.5 | 0.4 |
| | 92 | — | — | 7 | 1 | — |
| Leddell's ... ... ... | 90 | — | — | 5 | — | 5 |
| | 89 | 1 | — | 6 | 1 | 3 |
| (b) | 88.5 | — | — | 4.5 | — | 2.5 |
| | 88 | 5.5 | — | 5 | 1.5 | — |
| Leddell's ... ... ... | 87.5 | — | — | 6.5 | — | 6 |
| Shonberg's ... ... ... | 87 | 10 | — | 3 | — | — |
| Lumen bronze ... ... | 86 | — | — | 10 | — | 4 |
| | 85 | 5 | — | 5 | — | 5 |
| Ledebur's ... ... ... | 85 | — | — | 5 | 10 | — |
| Salge's ... ... ... | 84 | 9.9 | 1.1 | 4 | 1 | — |
| | 83 | 5 | — | 10 | — | 2 |
| Stratton's ... ... ... | 83 | 6 | 10 | 1.5 | 0.5 | — |
| Anti friction ... (c) | 82 | 6.5 | 6.5 | 5 | — | — |
| Fenton's ... ... ... | 79 | 14 | — | 6 | 1 | — |
| Ledebur's ... ... ... | 76 | 17.5 | — | 5 | 1.5 | — |
| | 74 | 15 | — | 5 | — | 6 |
| | 74 | 12 | — | 11 | — | 3 |
| | 73 | 19 | — | 5 | 2 | 1 |
| High copper ... ... | 47 | 31 | — | 20 | — | 2 |
| Parson's white bronze (d) | 38.5 | 56.5 | 0.5 | 2.5 | 1.5 | 0.5 |
| Bearing bronze ... ... | 29 | 65 | — | 4.5 | 1.5 | — |
| Electrotype... ... ... | — | 3 | 93 | — | 4 | — |
| Russian railroad car ... | — | 2 | 90 | — | 8 | — |
| Ordinary bearing... (e) | — | 6 | 87 | — | 7 | — |
| Jacoby metal ... ... | — | 5 | 85 | — | 10 | — |
| Linotype ... ... ... | — | 5 | 83 | — | 12 | — |
| Magnolia ... ... ... | — | 5 | 80 | — | 15 | — |
| | — | 10 | 80 | — | 10 | — |
| Railroad bearing... ... | — | 10 | 75 | — | 15 | — |
| Monotype ... ... ... | — | 8 | 74 | — | 18 | — |
| Standard white metal ... | — | 5 | 71 | — | 24 | — |
| Graphite metal ... ... | — | 15 | 68 | — | 17 | — |
| | — | 10 | 65 | — | 25 | — |
| Railroad bearing... ... | — | 20 | 60 | — | 20 | — |
| Standard type ... ... | — | 15 | 58 | 1 | 26 | — |
| Hoyle's metal ... .. | — | 46 | 42 | — | 12 | — |
| Italian railroad car ... | — | 37 | 38 | — | 25 | — |

(a) High tensile and low ductility.
(b) Phosphor-copper, 4.5 per cent.
(c) Heavy duty. (d) Analysis. (e) Heavy load.

The best alloys for die-castings are made by combining the metals in such a manner that they will enter into solution with one another with no part of them segregating. Segregation often occurs in the centre or interior of metals by one element remaining in suspension in the other while it is freezing. Then again, two metals may enter into solution with one another when they are in the molten state, but when the temperature is lowered and they begin to solidify segregation or a separation takes place. The molecules of metal that form the various mixtures are not bound together by a cohesive force that is strong enough to make them nearly approach the physical properties of the alloys. Thus castings made from them are not as successful for commercial uses.

As high as 20 per cent. of lead can be made to enter into solution with copper and form a homogeneous alloy, but when more lead than this is used it begins to segregate, and 30 or 40 per cent. of lead added to 70 or 60 per cent. of copper will only make a mixture. Of zinc and aluminium 50 per cent. of each can be made into a mixture that will give fairly good results when first cast, but they disintegrate to such an extent that the castings crumble into small particles within a year.

### The Mechanical Work of Die-Casting.

The mechanical work of manufacturing die-castings also needs careful attention, as good alloys can be spoiled in these operations. It is necessary to have the alloys well protected from the air while making them into castings. If this is not done the metals are liable to absorb gases, which may become occluded or segregate enough to form microscopical bubbles or even in large enough quantities to form blow-holes. This, of course, destroys the cohesive force between the molecules separated by these gases and weakens the metal.

With some styles of die-casting machines air pressure has been used over the surface of the bath to force the metal into the moulds. This forces air into the molten metal and never results in good castings. In others mechanical means have been used to force the metal into the moulds, but nearly always in such a way as would continually keep the bath churned. This draws the gases from the air into the molten metal. Under such conditions the longer the casting machine is operated the poorer will be the castings, as it does not allow the bath to remain quiet for a long enough time for the gas bubbles to rise to the surface, as they would do if not occluded. If castings made under these conditions are broken, the holes formed by the gases can often be seen with the naked eye. If not, a small magnifying glass will bring them out clearly. A pronounced segregation of any of the various metals can often be seen also.

In the mechanical operation of making die-castings, therefore, it is of considerable importance to have the retort that holds the molten metal tightly covered and thus protected from the outside atmosphere. The bath should also be kept covered with a flux, to prevent any air that may be in the retort from coming in contact with the metal. Common salt is one of the best fluxes for this purpose. In addition to this the machine should be so designed as to prevent the bath of molten metal from being put in motion when forcing a portion of it into the die mould.

### Zinc and Copper.

Of the metals used in manufacturing alloys for high tensile die-castings, zinc has been by far the largest ingredient, varying from 73 to 93 per cent. In some bearing metals that have been termed white bronzes a zinc content of from 30 to 40 per cent. is used with a high percentage of tin. One alloy that carried 20 per cent. of copper had a zinc content of 47 per cent., with the tin 31 per cent., and aluminium 2 per cent.

Zinc belongs to the same chemical group as cadium and mercury, and has a strong resemblance to magnesium. It occurs in nature in combination with carbon and oxygen or with sulphur or with silicon and oxygen. Zinc ores are first converted into an oxide by roasting, and the oxides then reduced by heating them with charcoal. This product is called spelter, and is not pure. The impurities present are lead and iron, and sometimes arsenic and cadmium. Zinc has a brilliant lustre of a bluish-white colour, and at the ordinary temperatures it is very brittle, with a highly crystalline structure. At from 200 to 300 degrees F. it is easily rolled into sheets, but above 400 degrees it again becomes brittle. It melts at 786 degrees, and casts very crystalline if the temperature is raised much above this.

Zinc gives die-castings the proper degree of hardness, but, as it is very low in ductility, other metals have to be added to correct this quality. Alloys with the higher percentages of zinc are quite brittle, but have a greater hardness than when the zinc is low. The toughness can be increased by lowering the zinc content, but it will sacrifice some of the hardness. The required toughness is usually obtained by adding copper to the zinc, but much over 10 per cent. of copper cannot be added, as it raises the melting point of alloys to temperatures at which they will not cast successfully in metal moulds.

When from 3 to 5 per cent. of copper is added to zinc it gives the alloy a whiter colour than that of pure zinc. The colour of the copper does not show in the metal until from 20 to 25 per cent. has been used. After this the higher the percentage of copper the more pronounced will be the copper colour.

Copper melts at 1,980 degrees F. Thus, if die-casting alloys are very high in copper the metal from which the die-moulds are made oxidises. This formation of oxide occurs at a temperature considerably below the melting point of copper and causes the surface of the dies to wear away when but few castings have been made. Unless a large number can be made to the correct size before the die-moulds give out, the die-castings are not a commercial success. The higher the copper content the sooner will the die-mould be destroyed. In the zinc-base alloys used for die-moulded castings, copper is used to overcome the crystalline nature of zinc. Copper adds toughness, but does not confer any great strength. Other metals are depended on for this.

As silver belongs to the same chemical group as copper it has been used as an alloying material with more or less success. Its high cost, however, prohibits its use for ordinary purposes. It melts at 1,762 degrees F., is softer than copper, and is extremely ductile and malleable, with a good tenacity. It is one of the best conductors of heat and electricity.

### Tin.

Tin belongs to the same chemical group as lead, and nearly always occurs in nature in combination with oxygen, in which case there are two parts of oxygen to one of tin. It melts at 450 degrees F. One peculiar feature of tin is that when a temperature of 50 degrees below zero F. is reached it slowly assumes a grey colour, is very brittle, and the specific gravity is lowered. It then begins to crumble, and this is known as the tin pest. Hence tin cannot be used in very cold countries.

Tin ranges between nothing and 20 per cent. in die-casting alloys that require strength and toughness. It is then nearly always used in combination with copper and zinc, with a little antimony added. In a high-copper alloy, however, the tin content was made 31 per cent., and as high as 65 per cent. has been used in anti-friction alloys.

The strongest, toughest and best die-casting alloys contain from 5 to 10 per cent. of tin. With a high tin percentage die-castings have a very smooth surface, as the alloys seem to spread or flow over the surface of the steel mould better than when but little or no tin is used. Scraper marks put on the surface of the die-mould are plainly reproduced in the castings and all projections and corners are sharply defined. Tin also makes the highest-priced alloy, but the majority of die-castings are of such small size that the price of the metal is not as much of a factor as the physical properties.

With a tin content ranging between 55 and 65 per cent., a zinc content of 30 to 40 per cent. and the copper from 2 to 5 per cent., with about 1.5 per cent. of antimony, a very good bearing metal can be made, and this can be cast accurately to size in the die-casting machines. Parson's white bronze is similar to this in composition. It is much harder and wears longer than the lead-base bearing metals that contain a high percentage of antimony and a low percentage of tin. The latter is about one-third of the price of the former, but the former better withstands the hard usage given to bearings that are designed for parts similar to the crankshaft of an internal combustion engine.

### Lead.

In the strong, tough alloys lead is never used, but many die-castings are made from alloys having a lead base and containing high percentages of antimony. The tin in these ordinarily varies from 2 to 20 per cent., but in some of the bearing alloys as high as 46 per cent. has been used, with 42 per cent. of lead and 12 per cent. of antimony. The lead ordinarily varies from 58 to 93 per cent., and the antimony from 4 to 26 per cent. These alloys were first perfected for use in anti-frictional bearings, and later for casting into type in metal moulds. Here the die-casting of machine parts started. Bearings were cast accurately to size in die-moulds and small instrument and machine parts that required no particular strength, toughness, etc., were die-cast from these alloys. After this the alloys were much improved in their physical properties and machine parts were die-cast from better metals.

The properties of lead make it especially applicable for die-castings, but its shrinkage is so great, its tensile and compressive strength so very low and its softness such that it has to be alloyed with other metals that overcome these faults. Lead only enters into solution with zinc to a very limited degree, and hence they are seldom used in the same composition. No matter how well they may be mixed in the liquid state, they separate into layers before the temperature is lowered to the freezing point. The zinc layer carries a very small percentage of lead in solution, and the lead layer has a very small percentage of zinc in solution.

When heated to between 1,650 and 1,800 degrees F. lead and zinc enter into complete solution, but as this temperature is lowered they continue to separate until the freezing temperature is reached. If it were possible to cool them suddenly from the temperature above mentioned, the total solubility could be retained. The longer the elapsed period of time during which the temperature is lowering from 1,650 degrees to the freezing point, the more complete will be the separation of the metals. The oftener these metals are melted and cooled the more complete also will be the separation.

### Antimony and Bismuth.

Antimony imparts hardness to lead, and hence the degree of hardness that is desired in type or bearing metals can be obtained by varying the percentage of antimony. It also imparts hardness to die-casting alloys. It has one peculiar property, which is that when freezing from the liquid state it expands like water, instead of contracting like most metals. This is a valuable property for alloys used in the manufacture of die-castings, and hence it can be found in nearly all of them. From 1 to 2 per cent. seems to be sufficient, when acting in conjunction with the pressure under which the alloy is injected into the mould, to overcome the shrinkage imparted by the other metals.

Experiments have shown that pure antimony increases the expansion of pure lead in proportion to the percentage used, until the maximum expansion is attained when the antimony content reaches 13 per cent. This is the eutectic alloy, and it melts at 443 degrees F. When more than 13 per cent. of antimony is used the expansion is lowered until it reaches a minimum at about 35 per cent. antimony. It then rises again to a second maximum with about 50 per cent. antimony, after which it again lowers and then rises until pure antimony is reached. It may seem queer that, while pure lead melts at 621 degrees F. and pure antimony at 1,166 degrees F., a combination of the two will cause the melting temperature to lower to 443 degrees F. Many of the die-casting alloys given in the table, however, exhibit the same phenomena in melting temperatures; they being lower than the average melting temperature of the various ingredients.

Antimony gradually increases the hardness of lead until a content of 13 per cent. has been reached. From there to 17.3 per cent. of antimony a more gradual rise in hardness is made, and at this latter point the maximum hardness is attained. After 80 per cent. antimony has been passed the hardness again falls very rapidly down to that of the pure antimony. An alloy containing 32.5 per cent. of antimony and 76.5 per cent. of lead is four times as hard as pure lead.

Good, sharp castings, in which the details are brought out plainly, are obtained when the alloys contain from 15 to 25 per cent. of antimony, as the expansion then produced causes the metal to completely fill the mould. With an alloy containing about 20 per cent. of antimony, very good casting properties are obtained with a high degree of hardness.

While bismuth has this same property, it costs nearly 25 times as much as antimony, and it is thus seldom used in die-castings. Bismuth, however, melts at 520 degrees F., and this gives it an advantage over antimony in some places. Bismuth expands to a greater degree than antimony on passing from the liquid to the solid state, and this also gives it an advantage where cost is not a factor. The desired results, however, can nearly always be obtained with antimony.

### Aluminium,

Small percentages of aluminium are used in nearly all of the high grade die-casting alloys. This usually ranges from 0.5 per cent. to 6 per cent. In this range it is used for its strength-giving as well as its purifying qualities. While copper is used in the alloys with a zinc base to overcome their crystalline nature, aluminium or tin or both are used to confer strength. Aluminium has proved to be the better of the two elements for this purpose. Tin adds a certain amount of ductility to the zinc-copper alloys, but they lack the stiffness and fluidity that is imparted by aluminium. By adding 3 per cent. of aluminium to an alloy containing about 10 per cent. copper and the remainder zinc, the strength of the metal will be increased fivefold. Antimony has proved to be of little benefit in this regard, and manganese has proved to be detrimental, as it makes the metal run more sluggishly, without adding any beneficial properties. Phosphorus, on the other hand, has proved to increase the strength of the zinc alloys containing copper and aluminium, and the one in the table showing a phosphor-copper content of 4.5 per cent. proved to be stronger than cast-iron.

Some of the aluminium alloys, that is, those that have aluminium for the base, are being cast in die-casting machines, but it is necessary to use ingredients that will lower the melting point of aluminium, which is 1,215 degrees F. The oxide of aluminium forms so quickly on its surface that this also creates difficulties that have to be overcome when die-casting it. A composition that is fairly high in zinc, and contains enough copper to give it the required toughness, can be successfully cast.

### Silicon, Sodium and Calcium.

Owing to the fact that silicon affects brass in nearly the same manner as aluminium, and aluminium greatly improves the brass mixtures, some experiments were carried out to see if it would have a similar influence on the zinc-base alloys that contained small percentages of copper. It seemed to work differently on these alloys, however, as when as high as 11 per cent. of silico-copper was used, in place of the ordinary copper, the silicon seemed to have no effect, as it neither increased nor decreased the strength of the alloy. This was also the case even when aluminium was added to the mixture.

Sodium, like other alkaline impurities, offers no resistance to the destructive influences of the dampness of air. It has a bad effect on alloys with a low copper percentage, and together with all other alkaline impurities should be kept out of die-casting alloys.

Calcium, however, produces such a feeble alkaline solution that it might act as a good deoxidiser, and, if more uses were found for it, its price could be made cheap enough for practical purposes. Unless it should show superiority to the many other deoxidisers on the market, however, it would find little use. It melts at 1,480 degrees F.

### Nickel, Titanium and Cadmium.

Nickel has added such good properties to steel that it is continually being experimented with in the non-ferrous alloys. It alloys readily with aluminium and increases its elasticity. It has been used in small percentages in some of the die-casting alloys, and has proved beneficial. Enough is known to warrant the assumption that when the proper combination with other metals is discovered nickel will prove to be a useful metal for an alloying material. Its melting temperature, however, of 2,640 degrees F. is too high for it to be used in any but homœopathic doses.

Titanium is fast coming into use as a purifier and an alloying element, and this will doubtless add good properties to the die-casting alloys. It has a great affinity for oxygen and nitrogen, and should be of especial benefit in removing these gases, when the best manner of using it is known. These gases have proved to be very injurious in die-casting alloys. When not more than 3 per cent. is used, titanium has a good influence on aluminium, and with a 2 per cent. titanium content, aluminium alloys show greatly improved resistances to tensile stresses. It has also been proved of special benefit to copper and brass and bronze mixtures, and thus should be of special benefit to the zinc-copper-aluminium die-casting alloys.

Cadmium belongs to the same chemical group as zinc, and is very similar to magnesium, but is not as common as either of these. It is harder than tin, and has a very similar colour. It is whiter and less crystalline than zinc. It melts at 610 degrees F. It should thus be of especial benefit to die-casting alloys, if it were obtainable and the proper combinations were discovered. Zinc and cadmium enter into solution in all proportions, and remain so at all temperatures. These show the extreme of metal's solubility, and compare with the liquids, alcohol and water.

### America's Earliest Iron Works.

The beginnings of the iron industry in America were not made in the United States, says the "Mining and Engineering World." In the year 1590 a few venturesome souls set out in an exploring party from the town of Sao Paulo, Brazil, which had been settled by the Portuguese some 40 years previously. A "mountain of iron ore" was discovered some 62 miles to the west, and gold and silver were also reported, Portugal in 1297 sent out a commission to encourage the mining industries in Brazil, and a practical iron-founder was included in the party. About 1600 one or two small forges were set up, and were operated until 1629. The locality later became known as Ipanema, whose iron works are thus seen to have started several years prior to the settlement of Jamestown in 1607. In fact, about 1600 an additional forge had been operated near the settlement at Sao Paulo to work the clayey ironstone ore of the immediate vicinity.

## Experiments on the Strength and Fatigue Properties of Welded Joints in Iron and Steel.*

By T. E. Stanton, D.Sc., and J. R. Pannell.

These experiments were undertaken at the suggestion of Sir John Wolfe Barry in 1908, the object being to obtain a comparison of certain properties of welded joints—made by different processes and by different makers—with the corresponding properties of the unwelded material from which the joints were made. It was hoped that by this means some estimate of the general reliability and efficiency of modern welding processes might be arrived at. In order to obtain material for the work a circular letter was sent from the National Physical Laboratory to various engineers, inviting them to submit specimens of welded joints for testing. Sixteen firms responded to this invitation, and the total number of welded joints received was 167. The method of welding and treatment of the joints was left entirely to the makers, the only condition being that all specimens should be made from bars 1¼ in. in diameter. The tests to which the joints were subjected were: First, a tensile test, and secondly, a fatigue test by the Wöhler method. The former included determinations of the elastic limit, the yield point, the maximum stress, the total elongation, and the general and local elongations.

For the rapid carrying out of the fatigue tests a machine was constructed in which the specimen was rotated at a speed of 2,200 revolutions per minute. Owing to the results of a previous investigator with another type of machine having shown a decided reduction of fatigue strength with increased rapidity of stress alternation, preliminary experiments were carried out to determine the amount of this effect for the particular type of machine used. The results showed that for speeds of 200 and 2,200 reversals per minute there was practically no difference in the fatigue strength. The assumption was therefore made that the apparent reduction of fatigue strength with rapidity of alternation in the case referred to was a characteristic of the machine used.

The mean result of the tensile tests on the welded joints, expressed as a percentage of the strength of the original material from which the joints were made, were:—

| | Per cent. |
|---|---|
| Hand-welded iron ... ... ... ... ... | 89.3 |
| Hand-welded steel ... ... ... ... ... | 81.6 |
| Electrically-welded iron ... ... ... ... | 89.2 |
| Electrically-welded steel ... ... ... ... | 93.4 |

Joints made by the oxy-acetylene process were also submitted by two makers, but the results were not comparable with those obtained by the hand or electric processes.

The various determinations made in the tensile tests showed a distinct want of uniformity in the material in the region of a weld, but the results of the fatigue tests proved that this does not materially affect its resistance to reversals of stress. When failure under alternating stresses of low value takes place, it is invariably due to a defect in the actual weld itself. The number of defective joints which were discovered in the whole investigation, however, leads to the broad conclusion that in important work, where the failure of any particular welded joint may involve serious damage to the structure, the subjection of each joint to a proof-load is still desirable.

* Abstract of a Paper read, December 12, before the Institution of Civil Engineers.

# Centrifugal Fans for Cupolas.

By E. L. Joselin.

Before the Birmingham Branch of the British Foundrymen's Association, on November 25, a Paper on "Centrifugal Fans for Cupolas," was read by Mr. E. L. Joselin. Mr. H. L. Reason (President of the Branch) was in the Chair. The Paper was illustrated with a number of slides.

### Centrifugal Fans for Cupolas.

For some time past there has been an increasing demand for centrifugal fans for blowing cupolas, and their adoption has not always met with the desired success. The inquiry has thus arisen as to whether high or low pressures are best, and this has involved the still keen rivalry of the Roots' blower versus the centrifugal fan. The author does not offer the fan as the universal panacea for cupola troubles; there are cases where the Roots' blower is essential to sucess, others where

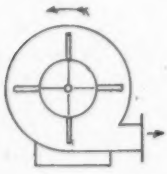


FIG. 1.

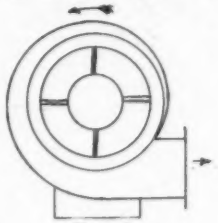


FIG. 2.

the fan could with advantage be applied, and others again where the fan could be adopted if certain alterations were carried out. It is the author's desire, by a discussion of the characteristics of the fan, to assist foundrymen to determine the conditions under which they may with advantage adopt it.

In its early form the centrifugal fan consisted merely of two or four paddles revolving in a more or less circular case with an outlet somewhere in its circumference (Fig. 1). It has been the subject of numberless attempts at improvement (1) in the shape of the

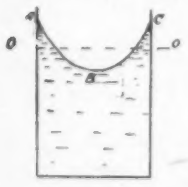



FIG. 4.

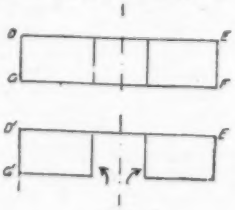



FIG. 5.

vanes; (2) in the shape of the case, and (3) in the mechanical details, such as bearings, etc.

The vanes will be discussed a little later. The chief improvements in the casing have been along lines similar to the centrifugal pump, viz., a diffusing chamber and a gradually increasing section of the casing, as shown in Fig. 2. The bearing improvements are legion, and comprise various types of extra long bearings, some fixed, others free to swivel in one or more directions, or universally by means of spherical seatings; lubrication by means of oil box, wick, oil rings and force pump have been used; and most recently ball bearings have come to the front. Some of these details are illustrated in Fig. 3.

Consider now the action of a centrifugal fan. Fig. 4 shows a vessel of water, the latter having been stirred till it has assumed the well-known concave form. The centre has its level lowered, and the circumference is raised. The level of points A and C above O O is equal to the fall of B below O O, and the total difference of level between A and B is found to depend on the square of the actual velocity of the water at A. Suppose it were in a closed vessel, as D, E, F, G, Fig. 5, then the water would press on the vessel with forces represented by the respective levels, as in the first diagram. At all points the pressure is that due to velocity of liquid, and the difference of pressure between centre and circumference is equal to the height corresponding to the velocity of the liquid at the circumference. The same occurs with air.

One other point must be considered, viz., in a fan the air is flowing radially from centre to circumference, as indicated by the arrows in D', E', F', G', Fig. 5. It is found that air introduced centrally and flowing

FIG. 3.

radially between two parallel plates, decreases in velocity and increases in pressure. This radial flow is found, therefore, not to interfere with the pressure due to circumferential velocity, provided it is kept within a certain limit. If this limit is exceeded the pressure drops.

How is the pressure influenced by the shape of the vanes? The diagrams, Fig. 6, show various forms of vanes. In each case the fan-wheel is supposed to be revolving in the direction shown by the arrow, and the line A B represents the velocity of the rim of the wheel, the line A C the relative velocity of air leaving the vane, and these two combine to give A D the actual speed and direction of the air. The first (*a*) is a simple radial vane. There is a shock at the inlet, and it is not very efficient. The second (*b*) is a modification of the first to obviate the shock at inlet. The third (*c*) has been a popular form, of the same style as the centrifugal pump. Its effect is to deliver the air at a low velocity, and under certain conditions can be made highly efficient. But it necessitates high speeds. The fourth type (*d*) is peculiar in that it delivers the air at a velocity much greater than that

of the circumference of the fan. Unless this high velocity is carefully handled it may result in much loss of power. The result then will depend on the form of the casing.

Now, the law of the energy of fluids is that, neglecting differences of level which are of small account, the total of

Velocity energy + pressure energy = constant.

If, therefore, we have a fluid at high velocity, we can by means of a suitable enlarging case reduce the velocity, its value appearing in a corresponding amount of pressure energy.

Mention has been made of the connection between the pressure and velocity of air. The laws governing the flow of air are exactly similar to those for water. If water is allowed to escape from a jet or hole at a distance H feet below the surface, and if v is the velocity of the escaping jet of water in feet per second, the well-known formula is: $v^2 = 2g\ H$ (g being the value of gravity), and since head of water (in feet) multiplied by weight of one cubic foot is equal to pressure per square foot, we can write it: —

$$v^2 = 2g \times \frac{p}{D}$$

where p = pressure per square foot (in lbs.) and D = weight of a cubic foot (lbs.).

This is exactly true for air. Taking air at tempera ture 50 deg. F. anl barometer at 30 inches, this works out to

$$v^2 = 4290\ i \quad (i = \text{inches water gauge}).$$

Using this formula, the table of volumes discharged through nozzles has been calculated: —

*Volume discharged by Nozzles, Jets or Tuyeres of various diameters at different pressures.*

| Pressure. | | Discharge—cubic feet per minute for diameters. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Inches of water | Ounces per square inch. | 1 inch. | 2 inches. | 3 inches. | 4 inches. | 5 inches. | 6 inches. | 7 inches. | 8 inches. | 9 inches. | 10 inches. |
| 2 | 1.16 | 30 | 118 | 265 | 472 | 737 | 1,060 | 1,445 | 1,885 | 2,380 | 2,950 |
| 3 | 1.73 | 36 | 145 | 326 | 581 | 907 | 1,305 | 1,730 | 2,320 | 2,940 | 3,630 |
| 4 | 2.32 | 42 | 166 | 374 | 665 | 1,040 | 1,495 | 2,040 | 2,660 | 3,360 | 4,160 |
| 5 | 2.89 | 46 | 185 | 416 | 740 | 1,155 | 1,665 | 2,260 | 2,950 | 3,740 | 4,620 |
| 6 | 3.46 | 50 | 203 | 456 | 810 | 1,267 | 1,820 | 2,480 | 3,240 | 4,100 | 5,070 |
| 7 | 4.05 | 55 | 221 | 497 | 884 | 1,380 | 1,990 | 2,710 | 3,530 | 4,470 | 5,520 |
| 8 | 4.63 | 59 | 236 | 530 | 945 | 1,475 | 2,120 | 2,890 | 3,775 | 4,780 | 5,900 |
| 9 | 5.20 | 62 | 248 | 558 | 992 | 1,550 | 2,230 | 3.040 | 3,960 | 5.020 | 6,200 |
| 10 | 5.78 | 66 | 263 | 592 | 1,053 | 1,645 | 2,370 | 3,220 | 4,210 | 5,330 | 6,580 |
| 11 | 6.35 | 69 | 275 | 620 | 1,100 | 1,722 | 2,480 | 3,370 | 4,410 | 5,570 | 6,890 |
| 12 | 6.92 | 72 | 288 | 648 | 1,150 | 1,800 | 2,590 | 3.520 | 4,600 | 5.830 | 7.200 |
| 13 | 7.50 | 75 | 300 | 675 | 1,200 | 1,875 | 2,700 | 3,680 | 4,800 | 6,070 | 7,500 |
| 14 | 8.10 | 78 | 312 | 702 | 1,248 | 1,950 | 2,810 | 3 820 | 4,980 | 6,320 | 7,800 |
| 15 | 8.70 | 81 | 324 | 729 | 1,295 | 2,025 | 2,910 | 3,970 | 5,180 | 6,550 | 8,100 |
| 16 | 9.26 | 83 | 333 | 748 | 1,330 | 2,080 | 3,000 | 4,080 | 5,330 | 6 730 | 8,320 |
| 17 | 9.83 | 86 | 345 | 777 | 1,380 | 2,157 | 3,110 | 4,230 | 5,520 | 7,000 | 8,630 |
| 18 | 10.40 | 88 | 354 | 796 | 1,415 | 2,212 | 3,180 | 4,340 | 5,6 0 | 7,170 | 8,850 |
| 19 | 11.00 | 91 | 363 | 817 | 1,450 | 2,270 | 3,270 | 4.450 | 5 810 | 7,350 | 9,080 |
| 20 | 11.58 | 93 | 372 | 837 | 1,490 | 2,325 | 3,350 | 4,550 | 5,950 | 7,530 | 9 300 |
| 21 | 12.15 | 95 | 382 | 860 | 1,525 | 2,380 | 3,430 | 4,670 | 6,100 | 7,720 | 9,540 |
| 22 | 12.70 | 97 | 390 | 878 | 1,560 | 2 440 | 3 510 | 4,780 | 6,240 | 7 900 | 9,750 |
| 23 | 13.30 | 100 | 400 | 900 | 1,600 | 2,500 | 3,600 | 4,900 | 6,400 | 8,100 | 10 000 |
| 24 | 13.85 | 102 | 40 | 918 | 1,632 | 2,550 | 3,670 | 5,000 | 6,520 | 8,2 0 | 10,200 |
| 25 | 14.40 | 104 | 416 | 936 | 1,664 | 2,600 | 3,740 | 5,100 | 6,650 | 8.420 | 10,400 |
| 26 | 15.00 | 106 | 424 | 954 | 1,696 | 2,650 | 3,810 | 5,190 | 6,780 | 8,580 | 10,600 |
| 27 | 15.60 | 108 | 432 | 972 | 1.728 | 2,700 | 3,880 | 5,290 | 6,900 | 8,750 | 10,800 |
| 28 | 16.20 | 110 | 442 | 994 | 1,770 | 2,760 | 3,980 | 5,420 | 7,070 | 8,950 | 11,050 |

**The above table is calculated for average British atmospheric conditions, viz., temperature, 50° F.; barometer, 30 inches.**

If air under pressure is allowed to discharge into the atmosphere, or into a space under a lower pressure, the velocity of discharge will be given by this formula, the pressure difference being taken; but the volume of air discharged will depend on the shape of the outlet. Various shapes are shown in Fig. 7, and against each is the fraction of the full area which represents the area of the discharge jet, and known as "coefficients of discharge," and the actual discharge from a given jet will be the corresponding fraction of the figure given in the table.

### Losses of Pressure.

There are many opportunities for air to lose its pressure. They may be summed up in two classes: (*a*) shock and (*b*) friction.

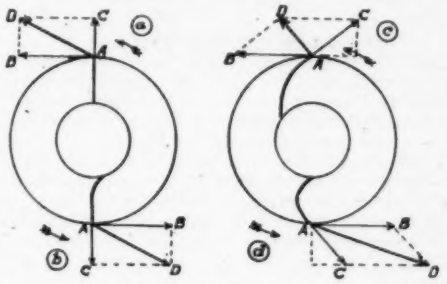



FIG. 6.

(*a*) Whenever moving air suddenly changes either its speed or its direction, there is a loss of pressure, and its amount is that due to the difference of the two velocities. Various arrangements producing this are clearly shown in Fig. 8.

(*b*) Air moving in contact with surfaces of pipes, or the blades and casing of fans, etc., is retarded by friction, and absorbs a certain amount of pressure.

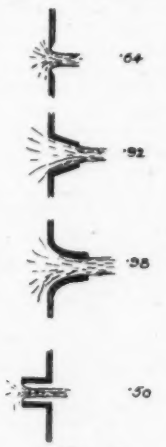



FIG. 7.

This friction increases in proportion to the square of the speed of the air, but in the case of pipes it decreases as the diameter increases.

### Measurement of Air Pressure.

The commonest way of measuring air pressure is by the ordinary water gauge. Care must be taken as to how it is applied. The illustration, Fig. 9, shows how the reading is influenced by the position of the gauge. The difference between the position "facing" the current, or *total gauge*, and that sideways to current, or *static gauge*, represents the velocity of the air, and may be used as a measure of such. The instrument known as the Pitot tube is based on this.

### Work Done by a Fan.

The diagram, Fig. 10, is a sort of fan-indicator-diagram. O F represents volume and F C pressure at inlet, O G and G D at outlet. Hence the shaded area is a measure of work done, and, neglecting the small triangle:—

Work done = A C × A B foot-lbs.
= volume in cu. ft. × pressure increase lbs. per square foot.

Since lbs. per sq. foot = 5.2 × water gauge, we get work done = volume × water gauge × 5.2, hence:—

$$\text{H.P.} = \frac{V \times 5{\cdot}2\,i}{33{,}000} \quad (i = \text{inches water}).$$

### On Selecting a Fan.

Unlike the centrifugal pump, a fan cannot be selected by the size of the outlet from the casing, especially for high pressures. The pressure required determines within narrow limits the speed of circumference of the fan, and if the revolutions per minute are restricted, the diameter becomes fixed.

As regards volume, every fan maker knows (or should know) a certain limiting output for each size of fan, beyond which the pressure falls off. This limit is most conveniently expressed by the area of outlet over which the fan will maintain the given pressure, and this area is called by some the "blast area," and by others the "orifice." The size of nozzle or orifice on which the fan will maintain the given pressure becomes the true measure of the fan, and this may be used as a good method of testing the fan, due regard being given to the "coefficient of discharge" of the outlet chosen.

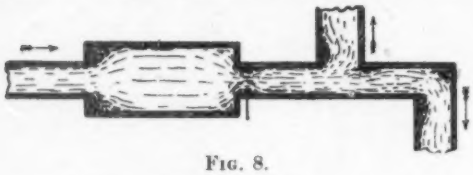


FIG. 8.

It will be interesting at this stage to compare the fan and the Roots' blower, first each at constant speed.

| FAN. | BLOWER. |
|---|---|
| Pressure is approx: constant. | Pressure varies with resistance. |
| Volume proportional to opening. | Volume approx. constant. |
| Power proportional to volume (approx.) | Power proportional to pressure (approx.) |

For any fixed size of orifice, for both fan and blower:—

Volume varies in proportion to speed (approx.)
Pressure varies in proportion to speed$^2$.
Power varies in proportion to speed$^3$.

Hence, with the fan the speed must be practically constant to maintain uniform pressure, and the volume can be varied by altering the orifice; while with the blower the volume can only be varied by altering the speed, the pressure increasing with diminished orifice; or constant pressure can be maintained by varying the speed of the blower.

### Efficiency.

For low pressures—say up to ½ lb. per sq. inch (14 in. w.g.)—the fan is at least equal to the blower in overall efficiency, *i.e.*, the ratio of power in discharged air to brake power put into shaft. The best makes of fan would be more efficient than the blower for low pressures. For pressures between ½ and ¾ lb. per sq. inch (14 in. to 21 in. w.g.), the fan and blower run closely in efficiency; which of the two is better depends on the make. For pressures above ¾ lb. per sq. inch the blower is in most cases more efficient. Large fans can be made of good efficiency up to 1 lb. per sq. inch. Multi-stage fans can be made highly efficient, but their cost soon begins to run the Roots' blower close.

A typical diagram, Fig. 11, illustrates how the pressure and efficiency of a fan vary at *constant speed* when the volume discharged varies. It will be noted

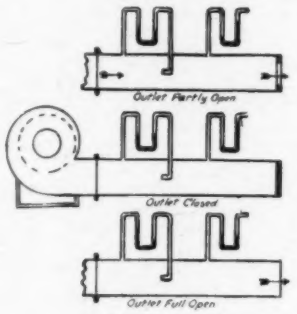



FIG. 9.

that there are three curves, connecting pressure, horse-power and efficiency with the volume of air discharged. The volume of air is controlled simply by varying the area of outlet. The pressure first rises slightly, and after a while falls off, till when the outlet is full open it falls to atmospheric pressure. The power, it should be noted, is lowest when the outlet is shut and gradually increases till it is full open. The efficiency, that is ratio of power in air to brake h.p. given to fan shaft, first increases to maximum and then falls away.

### Application of Fans to Cupolas.

We may state the problem thus:—

Given (1) that a certain proportion of coke is necessary, when burnt under proper conditions, to melt one ton of iron,

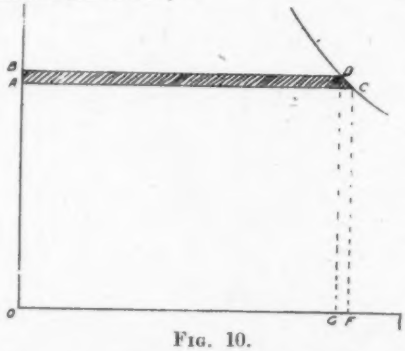



FIG. 10.

and (2) metal and coke charged in layers in a vertical tube,

to supply air to burn this coke quickly and completely, and drive away the products of combustion.

This resolves itself into three enquiries: (*a*) How much air is required to burn one lb. of coke; (*b*) how much coke is necessary to melt one ton of iron; and (*c*) what pressure is needed to overcome the resistances offered.

(*a*) is easily calculated. One lb. of carbon requires 2⅔ lbs. of oxygen for complete combustion, and at ordinary temperatures and pressure this is contained in

167 cub. ft. of air. Taking coke with 96 per cent. carbon, we require 160 cubic feet per pound.

(*b*) An ordinary good result would give about 180 lbs. of coke per ton melted, *i.e.*, a ratio of 1:12½. Therefore the air required is 180 x 160 = 30,400 cubic feet. This is a figure often quoted, though many allow more than this.

(*c*) The resistances to the passage of the air are:—

(1) In the pipes. This can be reduced to a very small amount by proper design.

(2) In the tuyeres. The illustration, Fig. 12, shows the common form of tuyere. Being circular,

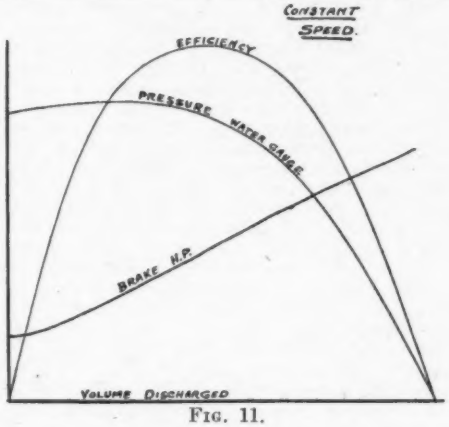



FIG. 11.

it soon reaches its maximum size, beyond which coke, etc., might fall into it. The American form has many advantages, as shown in Fig. 13. The effect of flaring is to give air a better chance of getting into cupola, while keeping the depth within limits. It enables the tuyeres to be kept to a narrower zone, and so lower the bed charge.

(3) In the cupola itself. The shape of the lining,

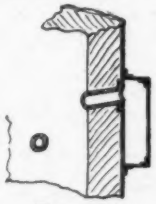


FIG. 12.

the method of charging, the height to charging door all have their effect in determining the resistance offered to the air.

### Examples.

The collection of reliable data on this subject is a difficult and slow process. The following will, however, prove interesting:—

I. Cupola, 20 in. internal diameter; tuyeres, 3 x 4 in., 3 x 3 in., and 3 x 2 in. diameter; ratio, area of cupola/tuyere area = 4.6:1; coke used per ton of iron melted = 1½ cwts., equal to 13⅓ lbs. iron melted per lb. of coke; air pressure, 16 in. w.g.; volume of air not known; iron, mixture of Gartsherrie pig and good machinery scrap; coke, Pease's.

II. Cupola, 24 in. dia. melting zone; tuyeres, 2 x 3¾ in. dia.; ratio, 19:1; coke used per ton of iron melted = 188 lbs., equal to 12 lbs. of iron melted per lb. of coke; air pressure, 9½ in. w.g.; volume of air not known.

The following data are abstracted from the table of cupola tests given by Mr. W. S. McQuillan before the American Foundrymen's Association in 1907:—

| Cupola. | A. | B. |
|---|---|---|
| Diameter (inside) ... | 54 in. ... ... | 60 in. |
| Tuyere area ... .... | 420 sq. in. ... | 420 sq. in. |
| Iron melted per lb. of coke | 7.5 ... ... | 8·3 |
| Blast pressure ... ... | 14 ozs. ... ... | 8 ozs. |
| Ratio of iron to fuel charged ... ... | 8·8 ... ... | 11·4 |
| For same output, fuel saved per ton of iron | — ... ... | ¼ cwt. |
| Power saved per ton of iron ... ... | — ... ... | 43% |

Thus by using the larger cupola and lower blast pressure a considerable saving could, in this example, be effected. It is interesting to note that increasing the smaller cupola by calculation so as to pass the same volume of air at lower pressure leads to the same result, a 60 in. cupola.

What happens when the air pressure to a given cupola is varied? Scarcely anyone seems to have tried this. A set of figures is furnished by Mr. Cook, the result of an accident. The blower pressure dropped from 14 oz. to 8 oz. and the cupola output from nine tons to about six tons per hour. Assuming that the charging was carried out in exactly the same way, we

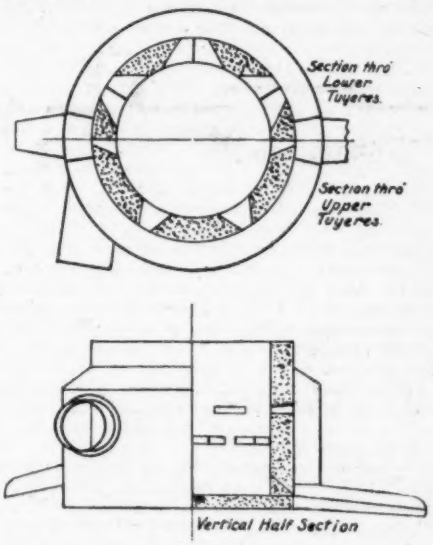



FIG. 13.

have a case of reduction of pressure on an orifice, and consequently the air supply would be expected to diminish as the square roots of the pressures, with it the coke consumed and with it the iron melted. This ratio is $\sqrt{\frac{14}{8}} = 1.32$, and $9 \div 1.32 = 6\frac{3}{4}$ tons per hour.

It would be interesting to hear of such a case in which the tuyeres were increased in the same ratio, and to know how near the output came up to the original. The author ventures the opinion that it would not reach above eight tons.

In other words, to sum up the matter, given a certain performance by a certain cupola at a relatively high pressure, the same result *can* be obtained at a lower pressure, but at the expense of a slightly larger cupola, with larger tuyeres, the set-off, however, being a saving in power practically in proportion of the two pressures. This saving in power becomes a very important factor in large cupolas, and as good results are being obtained with large cupolas and low pressures, it is certainly possible that considerable economy can be effected by the scientific adoption of fan blowing. It is well, however, to remember that this is not

a paper on cupola details or working, and that many other factors have to be considered in coming to a decision, and the matter should, therefore, be settled by everyone on the merits of his own case. Many will still continue both to use and advocate the Roots' blower, while many will run their foundry well and cheaply with the centrifugal fan.

**Discussion.**

Mr. H. L. Reason, in opening the discussion, said that the particulars Mr. Joselin had given them should be very useful in helping them to arrive at a definite conclusion as to whether fans or blowers should be chosen for particular purposes.

Mr. C. Heggie said that he thought the lecturer took the correct line in admitting that blowers were better than fans in many cases. But as to whether Mr. Joselin put the boundary line of pressure too high in favour of fans they would all probably have their own opinions. He thought the lecturer had made out a good case for fans. In deciding between fans and blowers, one item was first cost, and another the upkeep considered in connection with loss of efficiency by wear and tear. He took it that in the case of the blower most of the loss was caused by the contact of the surfaces, and when this took place the loss was considerable. The loss of efficiency in the case of the fan was chiefly due to the loss of pressure by friction of the air in passing through the fan, or when it was worked above or below its rated value. With regard to increasing the size of the cupola to get a greater melt, that, when it could be done, was an advantage in favour of the fan, as it could only be done in the case of a blower by increasing the speed or putting in a larger one.

Mr. John Shaw (Woodside Ironworks) was quite in agreement with the author that under proper conditions there was little to choose between the fan and the blower up to 14 oz. pressure. The crux of the whole question lay in the fact that with a blower in good condition they knew definitely what volume of air was being delivered per revolution; whereas with a fan the volume depended upon the resistance offered to the progress of the air. That, to his mind, was the weakness of the fan. Roughly put, a formula Mr. Joselin had given them stated that, with the same conditions, a rise in the horse-power of the engine meant an increase in volume delivered. West gave figures on this point, saying that with a 54-in. cupola it took 121 h.p. to maintain 1,800 revolutions per minute when the blast was put on; 76 h.p. during the middle part of the blow; a large increase of horse-power when blowing down, and only 33 h.p. when all the tuyeres were closed and no air was being delivered to the cupola. Whilst it was not possible to have their tuyeres quite bunged up, this showed what a very variable volume of air might be going into the cupola while the engine, if well governed, was running at the 1,800 revolutions per minute all the time. Whilst there were Pitot-tubes, anemometers and so on to measure the velocity of air in pipes, the former must be properly calibrated and then a formula used to obtain the volume for the size of pipe employed. They, as foundrymen, wanted to know what volume of air they were getting at any period of the blow, and it certainly would be to the interest of fan makers if they could put on the market a modified Pitot-tube with a self-recording apparatus showing the velocity of the blast at any period of the blow. A table showing various velocities and various-sized pipes, and giving the volume under those conditions, would enable any foreman to see what air he was receiving and to ease his engine by partially closing a valve at the beginning and the end of the blow, and reducing the volume when needed.

Mr. E. Morgan (Metropolitan Amalgamated Railway Carriage and Wagon Company) said that with reference to the cupola and the output, it was very interesting to all of them to get figures. But there was one thing which struck him, and which, no doubt, all of them had experienced, namely, that the quantity of iron they could melt with a ton of coke depended very much upon the quality of the coke. That was his experience. He was very much interested in the type of tuyere shown by Mr. Joselin as having been brought out by the Americans. He sincerely hoped it would be found that the Americans had given them a really good wrinkle.

Mr. D. Dalrymple (West Bromwich) seconded the vote of thanks.

Mr. R. Buchanan, in supporting it, said that as to the effect of different forms of blast on coke efficiency, he thought that 96 per cent. of carbon was too high a figure to take. He himself had never met with coke having so high a percentage of carbon. He had come across some cokes with about 94 per cent., but the general range was between 88 and 92 per cent. The high figure taken by the lecturer made a great deal of difference to the calculation as to the quantity of air required to ensure complete combustion. The relative merits of fans and blowers were constantly a subject of debate amongst foundrymen, but too commonly, in either case, the air was given the most rugged way to travel between the blowing apparatus and the cupola. That was a point which Mr. Joselin had brought before them very well—the great trouble which was put in the way of the travel of the air. In almost every foundry they would find these sharp angular take-offs more common than curved ones; one would find them especially in connection with the wind-boxes, which in themselves were considered by many foundrymen to be very useful contrivances.

Mr. Joselin, in reply, referred to the question raised by speakers as to the true boundary line of pressure at which a blower became more efficient than a fan, and said that, unfortunately, fans had not been reduced to absolute uniformity of design, so that no general statement as to the relative proportions of the steam-power to the fan or to the Roots' blower could be laid down. Probably, if they took half a dozen makes of blowing apparatus the designs and efficiencies would all vary so much that it would be impossible without naming the different makes, to say where the boundary line was likely to be. Undoubtedly, the upkeep of the fan was small in comparison with that of the blower, the wear being limited to the bearings, and the first cost was also much smaller. The first cost of a really good high-pressure fan would not be more than half that of a Roots' blower of corresponding capacity; and seeing that the machine had to stand still except for two or three hours in the day, one had to think before spending double the money. Mr. Shaw had put the case against the centrifugal fan in its most favourable light. It was certainly to be said against it that they wanted a definite volume of air and wanted to know what they were getting. It was not easy to meet that point in a positive manner. There were, he believed, one or two instruments for measuring the volume of air accurately and recording it, but these were very expensive. There might have been something cheaper come out, but he was not aware of it. He was grateful to Mr. Buchanan for his remarks about the coke. He (Mr. Joselin) had simply taken a book figure which he had come across, and he was quite aware there were poorer cokes in use.

The vote of thanks was carried amid applause.

# Pattern Making to Modern Requirements.

By T. R. Schofield.

At the meeting of the Lancashire Branch of the British Foundrymen's Association, held on November 4, Mr. T. R. Schofield presented a Paper on "Pattern-making to Modern Requirements," a full abstract of which is given herewith :—

### Modern Tendencies and Their Influence on Pattern-Work.

Modern developments in the engineering trade have made it essential to produce, commercially, castings of the greatest intricacy and precision. Never before has the demand for precision in foundry and pattern shop been so great, or complexity so multiplied in cast work. The aim is now to combine as much as possible in one piece, thus cutting out, to some extent, the work of machining and fitting together separate pieces, besides securing greater rigidity with the minimum of weight.

Patterns, from time immemorial, have been regarded as dead money; the pattern-maker and all his works are, according to many authorities, "necessary evils," "unproductive," etc. This is possibly very true, but it is surely no reason for assuming an attitude of grudging tolerance of the pattern-shop, and neglecting its claims to be equipped and run on lines more up-to-date than has been the case in time past. It is this parsimonious spirit which has given the pattern-shop the distinction of being the worst equipped and organised department of the works. I think it is no exaggeration to say that most patterns are made at low first cost only by jerry-building them, and leaving them in an unfinished state. Patterns which fulfil their purpose in the most efficient way, can be made at low cost, provided proper equipment and methods are employed.

Patterns which secure good, accurate castings, with minimum machining allowances, boss centres correct, while imposing the least amount of unnecessary labour on the moulder for their production, can be said to efficiently fulfill their purpose. Those which are undercut, or spring in ramming, and have to be almost broken out of the mould, those whose roughness brings the surface of the mould out with them when drawn, entail much work for the moulder, and a casting not as true as might be. In fact, stiffly made, reasonably-finished patterns are absolutely essential to economical casting production. In regard to economy, the pattern-shop and foundry might be considered jointly, and apparent economics in the former weighed against their effects in the foundry, in the shape of making up and mending the mould, and other work involved on each casting, which might be avoided. I do not desire to advocate refinement of our work, except so far as it secures better castings and patterns which will survive storage and demand the least amount of work for repairs, which is no mean item.

### Equipment Necessary for Economical Pattern-Making.

The surface table, angle plate and scribing block are indispensable for marking out castings in the fitting shop. The table should be as big as possible; it can be made equally serviceable in the pattern-shop. Large and small patterns can be built up on the surface table, and all setting out done in the only efficient manner.

A man building a machine bed on a true surface to start, by working parallel to sides and ends of table, can build up dead to size, and set out all centres with precision. If the table is level, he can sometimes usefully employ the plumb line in transferring direct the pattern contour to the core box, in cases where direct methods of setting out fail. Compare this with building up on the floor, where one has to make allowances for truing up, and after building up has to get a true face with the help of winding strips of doubtful accuracy.

Turning occupies a large portion of the pattern-maker's time, so that it should be worth while to see that the lathes provided are up-to-date enough to do good work at a good rate. Some evil genius decreed long ago that any crude apology for a lathe was good enough for turning patterns. Some lathes have a wooden bed, whose shivering fits prevent running at best speed, making both a rough and a slow job. The slide rest is often conspicuous by its absence, whereas it is one of the most useful and time-saving features a pattern-maker's lathe could have. A well-equipped, handy lathe, is one that a man can "get out of" as soon as possible; for turning is not a pattern-maker's favourite occupation.

It is perhaps not generally recognised to how many useful purposes a circular-saw bench of suitable design can be put in cutting down the cost of pattern-making. Machines adapted to the purpose have rip- and cross-cut saws on separate spindles driven by the same belt, a hand-wheel enabling either saw to be brought into operation while running, and to be set at any required height above the table, enabling grooving, rabbeting, half-lapping as well as the ordinary dimension sawing to be quickly and accurately done; work can be cut almost to the lines, leaving very little hand-work to be done. Another feature is the tilting of the table through 45 deg., useful for cutting lags for cylindrical patterns, wheel teeth, and a variety of jobs; and of particular interest is the movement for setting the fence out of parallel to the saw, by which half-circular core-boxes can be quickly roughed out, or wheel teeth hollowed to suit wheel-rim curvature. For cross-cutting, mitreing, checking sides of core boxes and similar work, a slitting fence, which swivels on a vertical pin, and can be locked at any angle, slides in a groove parallel to the saw; one of the uses to which it may be put is the cutting of the sides of thread on a worm blank, without any previous setting out, as will be shown later.

The large face-plate sander has long proved its usefulness in joinery and cabinet work, and it is, if anything, capable of wider application to pattern work; the irregular shapes of ribs, facings, bosses, prints, etc., being ground to correct shape and taper with the utmost ease. That it is not a toy is proved by the fact that a job such as a half-wheel rim, any diameter, and as wide as 12 in., can be ground down to the line, with correct taper, with a good finish, in a fraction of the time required by any other method. The men keep it in constant use, and it pays for itself in a very short time. When the author was serving his apprenticeship, the axiom most impressed on him was "*Not* to sandpaper, but to pare the work to shape"; now, everything possible is ground to shape on the sandpapering disc.

### Economies in Pattern Work.

It is desirable for the foreman, who naturally is best acquainted with foundry conditions, to thoroughly

study and decide beforehand, how the pattern shall be made; whether to be cored or to leave its own core, whether parts shall be loose, or made fast with a covering core up to the joint face, whether drawbacks will be necessary, and such essentials as must be decided before the job can be proceeded with. These decisions should be arrived at, where necessary, with the co-operation of the foundry manager, whose advice is of prime importance in avoiding those vexatious alterations sometimes found necessary when the pattern is unsuitable to foundry conditions.

A machine to plane timber to thickness enables work to be built true and to size with very little further attention; if the knives are cared for, wheels can be built with good joints without any hand planing—a big consideration.

Getting out and turning are taken care of as previously indicated. Useful in turning split patterns are a pair of turned steel plates, one to suit the driving centre, the other the core centre. On the periphery of each are teeth to embed in the end of pattern; circles are struck the diameter of plates on each end of the pattern, with the centre on the joint line, and the plates can be set into these circles and screwed on. This ensures the halves when turned being exactly alike and saves further setting.

Paring and carving are, of course, inevitable, but are reduced to a minimum in a pattern shop equipped in the manner outlined. The sand-papering disc, in particular, on irregular work, has done much in this direction. A pattern with a reasonable amount of finish leaves the sand well, and saves much of the touching up on the moulder's part which is sometimes in evidence on the casting; a moulder respects a decent pattern, and handles it carefully. Also a coat or two of varnish protects it in the foundry and in storage, where it often suffers more through drying and warping than in the bedding-in and rapping in the foundry.

### Two Jobs for the Dimension Saw.

The first is the semi-circular half-core box before mentioned; for example, say, 6 in. diameter, any length. The semi-circle is drawn on the ends of the box. Let us suppose $1\frac{1}{2}$ in. allowed on each side for dowel pins, then the extreme points of the semi-circle are $7\frac{1}{2}$ in. and $1\frac{1}{2}$ in. from one edge of the box, and the height is, of course, 3in. The rip saw is set with its highest tooth 3 in. above the table; the fence is then swing round until the teeth on table level are $7\frac{1}{2}$ in and $1\frac{1}{2}$ in. from the fence respectively; the fence is then locked in this position, the saw lowered, and the job passed over the saw successively, raising the saw $\frac{1}{4}$ in. each time until it is again 3 in. above the table, when it will touch three points of the semi-circle; the shape of the cut is elliptic or oval, and the remaining small portion is removed by hand.

The second job is the cutting of the sides of a thread on a worm pattern. Worm threads are, of course, usually turned in the lathe, but in those of moderate size, it is an advantage to have the thread relieved on the casting, especially in those of steel or bronze, as a better wearing face is secured, less machining required, and a lighter casting obtained. Any advantage of cost is somewhat off-set by the cost of relieving the thread on the pattern; a blank is turned the right diameter, and round this is wrapped tracing paper on which is drawn the development of the profile of the thread; the cutting of the groove is, by hand, a long and tedious process, and not very accurate at that.

This job can be done accurately on the circular saw, in a fraction of the time required by hand methods. Given the top and bottom diameters of the thread and the pitch, the angle of the thread at the mean diameter is easily found either by setting out or by calculation. This angle found, the slitting fence is swung out of perpendicular with the saw by that amount, forward or backward, depending on whether the thread is right- or left-handed. The shallow-toothed cross-cut saw is used, and is set to the depth of thread above the table. The blank is held against the fence, and moved forward until it is right over the centre of saw, the saw penetrating to the depth of the thread. If the blank be pushed endwise across the saw, it cannot move, as it bears against the blank part of saw, the teeth being shallower than the thread; the blank being rotated, however, it moves along endwise, the saw cutting on it a spiral of the right pitch, in less time than it takes to describe it. Of course, two cuts are necessary, one for each side of the thread; the remainder is soon removed with a chisel of suitable width. The teeth of the saw being shallower than the thread, the solid part of the saw below the teeth ensures uniform feeding as the job is rotated, and ensures correctness of pitch. Compared with hand work, this method takes about quarter the time.

### Tube with Internal Scroll.

This tube was required to be of cast iron, metal $\frac{1}{2}$ in. thick throughout, outside diameter $8\frac{1}{2}$ in., and length 53 in. What might be called the clear bore was $3\frac{3}{4}$ in. diameter, so that the scroll was $1\frac{1}{4}$ in. deep, its pitch being $3\frac{3}{4}$ in. The number required was not sufficient to justify a core box the full length, which would have been very costly to make, and simply a mass of loose pieces difficult to locate in the box; the method adopted was cheap in pattern making, and equally advantageous to the foundry. The castings did great credit to the founder, were uniform in thickness, free from chaplets, and had a smooth interior. The pattern was solid, turned $8\frac{1}{2}$ in. diameter by 53 in. long, with prints on each end, $7\frac{1}{2}$ in. diameter. In regard to the core, it was decided to make a core-box containing one thread of the scroll. Ten of these cores when assembled to form the complete core; the first and last of these cores differed from the rest, the other eight being all alike. The joint face between the cores required attention, as a straight cut across would cause feather edges, which would be unworkable. The joint was formed with a step $1\frac{7}{8}$ in. (half the pitch), which left plenty of sand round the thread, and also had the advantage of only one position in assembling, and imparting stiffness to the assembled cores.

The core-box was made in halves, $7\frac{1}{2}$ in. diameter, 12 in. long; the ends were closed in and a hole in the centre was bored $1\frac{1}{4}$ in. diameter, this being the size of the core-barrel on which cores were built. A print resting in these recesses formed a $1\frac{1}{4}$ in. hole right through each core. A parallel piece was next turned to $3\frac{3}{4}$ in. diameter; on this were fitted four equal segments, making a whole circle, 2 in. thick; this 2-in. collar was turned up to $7\frac{1}{2}$ in. to fit a box exactly; each was then moved along and secured $\frac{7}{8}$ in. in advance of previous one, so that the last was $3\frac{3}{4}$ in. in advance of the first. The spiral was soon set out by means of a triangular templet of paper, length equal to the circumference of the segments and height $3\frac{3}{4}$ in.

The segments, still on the $3\frac{3}{4}$-in. cylinder, were pared to this spiral, the cut being at every point square down on to the cylinder, this for the time serving as a paring block. This gave the true spiral surface to the thread; the other face was made in the same manner, after gauging $\frac{1}{2}$ in. parallel to the first. The thread was then finished off and was ready for the box. Before removing from its centre it was set in the box and scribed in each half correctly for locating afterwards; each piece was then

removed and set in the box to scribed lines and secured. Blocks at each end of the box gave the proper length and the staggered face to the cores. For the end cores, first one block and then the other were removed, and pieces inserted to give the required finish at each end. Each core was rammed from the joint face in halves, these being glued together before removing from the box. When baked, they were mounted on a 1¼-in. barrel and the corners rounded, the spiral matching all along perfectly; the core was very strong and could not be improved on.

A wheel with curved arms can also be made with advantage from cores, one arm in each; the joint is made staggered as in the previous example, thus avoiding cutting through the arm and consequent bad finish.

### A Hurry-Up Job in Wheel Making.

Another example of time-saving methods was a half-wheel pattern 40 in. diameter by 12 in. across the face of rim. The number of teeth was 72, and the pitch 1¾ in. The teeth were simple approximations to the finished tooth form, the wheel being afterwards machine cut, though they had to be accurately pitched on the pattern. The pattern required had central plate arms, ribbed up both sides to the rim, with bosses 12 in. diameter, provided with lugs for bolting together both at bosses and rim. The job was undertaken by three men, and work was so arranged that each could proceed independently, and so avoid hindering the others. The job was first carefully laid out full size, details of machining allowance, draft allowance, thicknesses of timber used, being shown, thus eliminating cut-and-try methods of building, and securing that each element was practically finished before building up, a little dressing off only being required. The pattern occupied 10 hours in making. The work was divided thus:

1st Man.—Building central plate arms and getting out timber for rim segments.

2nd man.—Building rim and paring insides of segments and getting out ribs.

3rd man.—Bosses and teeth.

All timber was machine-planed dead to thickness, practically no hand-planing being done. The arms were set out in four pieces, the arms at the joint being in one piece; they were band-sawn to the lines, the edges smoothed up and the corners rounded. The joints were trimmed and then assembled on the surface table; they were well held by corrugated steel fasteners, whose holding power is remarkable; the half-circle was completed with segments of the same thickness, fitted between the arms, and secured again with fasteners. The rim segments were band-sawn to the bevel and finished on the inside; these were built on to the central arms, three thicknesses each side, and set to the inside diameter, the outside being left rough; very little then sufficed to finish the inside of the rim. The outside diameter was struck, and the table of the sander was set to give 1-10th in. of taper and the outside of the rim ground down to the line. This took about half an hour, giving a finished surface with proper draft allowance. On this the centre lines of teeth were set out.

The bosses for each side were built in one piece to include the bolting lugs at the rim, and were made and finished ready to insert in the pattern. These were then secured in place with screws. When this was done, the ribs were fitted on each side of the arms and screwed up. While this was being done the teeth were hollowed to fit the rim, drilled, and fastened in place, working from each side towards the middle; the teeth were glued and screwed to the rim. Nothing then remained but to fit the print for the core, and the necessary work of dressing or filleting, etc.

The shape of the rim section was modified somewhat, being made up of straight lines, which reduced the work considerably, enabling the rim segments to be cut to the line and bevel on the band-saw. Without the sander, the rim would have to be turned, a very much longer job.

### Discussion.

The Chairman (Mr. F. Penlington) remarked that the lecturer spoke to a very sympathetic audience, when he pleaded for good patterns as against slovenly-made ones. As foundrymen, they had often had to complain of bad patterns, but never, in his experience, of their being better than was necessary.

Mr. R. W. Kenyon said he had been much impressed by Mr.Schofield's ingenuity in obtaining certain effects. He had every sympathy with the suggestion that nothing but good tools should be put into the hands of foremen. The Paper made them realise the great advantages which the younger generation were enjoying compared with their predecessors, and he trusted they would not fail to benefit by them. He had been amazed to find what work could be done on sand-papering discs, which in his earlier days they were warned against resorting to more than they could help. During a recent visit to a works, he saw some excellent developments of sand-papering discs which led him to lay down more plant on lines which enabled them to get out work more quickly and more efficiently. Mr. Schofield had referred to the way in which castings were now made as far as possible without loose parts, and they knew that that was the general tendency in all works at present. The new system was certainly superior to the old method in a variety of ways and operations.

Mr. J. Simkiss regarded the Paper, in the first place, as a direct hint to employers to provide their men with adequate machinery, so that they might get out their patterns properly and correctly. One of the objects of Mr. Schofield's address seemed to be to convince some makers that jerry-made patterns were neither the best nor the cheapest, and in his opinion he had succeeded in doing so. He was aware that Mr. Schofield had himself made some very intricate patterns, which must have taken him an hour or two to plan before entering upon the work; to fathom out the best means of making them with the extra parts fitted on instead of being loose. Cheapness in pattern-making was far from being the best economy. In the illustration given by Mr. Schofield, the fitment of the cores went together most perfectly, and the centres of the threads and the overall were very fine indeed. If firms would not allow pattern-makers to make good patterns they could not demand finished castings.

Mr. W. H. Sherburn said pattern-making had been looked upon in the past as a non-productive department. This, however, was a very short-sighted view. It might be non-productive for the moment, but he did not know what they would do without patterns.

Mr. D. Cordingley asked the lecturer what kind of gloss or varnish he considered the best coating for patterns to withstand the damp of the sand?

Mr. Schofield replied that he had found from experience that shellac made the best varnish.

The vote of thanks, having been seconded, was adopted unanimously and suitably acknowledged.

The Chairman, before closing the meeting, made one or two announcements of interest to the members. The fourth annual dinner will take place on January 13 next, and each member was desired to buy one, if not more, tickets.

# Moulding Sands.

## Green Sand, Dry Sand, Loam, and Skin-Dried Moulds, Cores, etc.

The extent of a moulder's practical knowledge of moulding sands and their application to various classes of work, depends upon his experience, observation and adaptability, coupled with keen enquiry into cause and effect. The subject of moulding sands, as associated with ironfoundry practice, is important, as sands of widely different quality are used, from a sharp sea-shore sand to a quarried sand containing a large percentage of clay. In the absence of clay, it is not of great importance whether the grains are rounded or angular; there will be little cohesion or adhesion. But when clay, or some other artificial binder, forms one of the constituents, either shape of grains will bind sufficient for all practical purposes.

Although it is not now intended to deal prominently with the analytical aspect of this subject, reference to analysis should not be omitted. It has been stated that there is no relation between binding power and plasticity, and the percentage of alumina present; also that neither rational nor ultimate analyses are reliable as representing the bond or silica present. The writer has had experience with many kinds of moulding sands in various parts of the country—green sand, dry sand, loam, etc.—and has had several selected samples of strong, medium and weak sands analysed; but it has not yet occurred that a strong sand gave in the ultimate analysis a low alumina content, or the weak sand a high alumina content, and it is noteworthy that the writer chose and named these different sands as "weak," "medium," and "strong," and sent them to the laboratory in utter ignorance of what the analysis would be. The sands were named simply according to the feel in the hand and the overhang when in a moist condition. The writer was at that time attempting, to a small extent, to standardise chemical analysis of moulding sands suitable for different kinds of work as regards thickness. As to plasticity, it must be apparent that such is obtained by the combination of water, or other liquids with the bond or clay constituent.

Moulding sands should be delivered within certain specifications, and there should be no waste, as the lumps can either be trodden, pounded or ground in a mill. Analysis should have some relation to the physical properties of the sands.

### Green-Sand Moulds.

In an ironfoundry a casting may be made in green sand, dry sand or loam. A mould may often be composed of the three; it is quite common for it to be composed either two of the three, and skin-dried moulds are not rare. It would be tedious to attempt to define the castings made by either of these ways, but, speaking generally, castings made in green sand are of a light character, and do not often run to many tons, except in the case of weights, lumpy pieces, plates and heavy foundry tackle, the appearance of which is not important. But green-sand castings, such as small engine and machine parts, tunnel and shaft segments, pulleys, chairs, tank plates, small pipes, valve connections, grate and ornamental work, must be turned out sound, clean and true in all respects.

As green sand contains moisture, more care has to be taken in ramming and venting than with a dry-sand mould, and to have a clean skin on green-sand castings, coal dust must be mixed with the facing sand, because when the molten iron comes in contact with the coal dust it generates a gas which deposits a protecting film or thin covering on the mould, which prevents the molten iron fusing the oxides and fusible silicates of the sand. This thin skin, covering, or film, will resist a higher temperature than that of the molten iron; in other words, the temperature of the molten iron will not decompose or dissolve the covering the coal dust has formed—that is, assuming that the right quantity of coal dust is mixed with the facing sand, which must be according to the thickness of the casting, the pouring temperature, etc. Foundry blacking will answer the same purpose as coal dust in producing a clean skin, but is much more expensive.

### Dry-Sand Moulds.

A large variety of castings, both heavy and light, such as condensers, cylinders, valves, bedplates, propeller blades, gear wheels, standards, ingot moulds, vertically-cast rams, columns, pipes, etc., are made in dry sand. A dry-sand mould favours harder ramming, and possibly less venting, permits rougher handling, and, apart from practical reasons for moulding in dry sand, such as large projections, drawbacks and parts that require much handling, the castings so made are mostly cleaner, sounder, and the mould more reliable than if made in green sand. The chief reason for this is that a dry-sand mould being baked there is no moisture to contend with; excessive moisture and molten iron when in contact always quarrel, and their disagreement invariably results in scabs, buckles, blisters, and blows. Although in a dry-sand mould the ordinary channels must be provided for the escape of gases, there is, in the absence of moisture and coal dust, much less gas to contend with; and, coupled with that, the mould being thoroughly dry makes the escape of gases through the walls of the mould much easier. Also, as a dry-sand mould is washed with a good blacking, it gives the casting a clean skin, and the mould is less liable to erosion from the wash of the iron when pouring.

### Loam Moulds.

There is scarcely any design of large castings but what can be made in loam, but not always economically. Although many small castings are made in loam to save pattern-making, generally speaking, loam castings comprise chiefly the largest circular castings, such as all kinds of cylinders, pipes, plain and with branches, large pans, wheels, etc., and many other large castings of irregular design. Most of these are made in loam from a practical and economical standpoint, regarding both the foundry and pattern shop. A loam mould is principally made from striking boards, strickles, etc., with a minimum of cost in the pattern shop. The mould is built up with bricks and milled loam, and the tackle, consisting of plain and prodded plates, binders, rings, etc., is principally made by the moulders, the cost being only the time spent in making them, melting of iron, etc. This is the cheapest form of tackle made in a foundry.

### Skin-Dried Moulds.

A large number of moulds are skin dried. These are practically green-sand moulds, the surfaces of which are either water-washed or blacking-washed. Skin drying reduces the moisture on the surface of the mould, thereby reducing the generation of hydrogen gas. Also, the smooth, firm, dry surface

minimises scabbing and erosion, giving the casting a clean smooth skin, like a dry-sand mould.

### Loam Cores.

A loam core is made of milled moulding sand ground, with the addition of water to give plasticity, manure and other material for porosity, and cow hair for cohesion. These materials are milled to a consistency which will vary according to work required. Many kinds of cores can be, and are, made in loam, in boxes swept up with strickles, and striking boards upon barrels, spindles, plates, core irons and rods of all shapes. These cores serve for such work as straight and irregular pipes, all kinds of cylinders, including steam passages, ports for large cylinders, and similar work.

### Dry-Sand Cores.

There is not a large variety of castings, large or small, for which dry-sand cores do not play an important part. Such cores are made in wood and iron core boxes, sometimes with the assistance of strickles, and often plain cores are made by a machine. In many instances a complete, or almost complete, mould forming an intricate casting is made of dry-sand cores when assembled for pouring. According to the class of work, so do dry-sand cores differ in strength and porosity.

### Green Sand and Skin-Dried Cores.

Green and skin-dried cores are similar to green and skin-dried moulds, and remarks under that heading equally apply. More often than otherwise these cores are left by the draught of the pattern, shell work being an exception, as the cores are formed by the inside of the patterns, which are in parts, and are made and lifted out from the pattern when the mould is being made—that is to say, the core and mould are made at one operation.

### Different Varieties of Moulds and Cores Considered.

As each of the foregoing methods requires a sand differing in quality and preparation, it may be advisable to enlarge on each separately, in the order enumerated.

Green sand contains moisture, but as regards how much or what percentage is allowable, there is a minimum and maximum for safe and successful moulding. If the sand is too dry it lacks cohesion; it does not hold together, but crumbles and falls away; hence it would be impossible to mould with sand in such a dry state. On the other hand, if the sand is too wet, moulding may be possible, but when the molten metal comes in contact with such sand, blows and scabs occur, as mentioned previously, by reason of the excessive moisture generating gases, which escape through the walls of the mould, but by endeavouring to do so penetrate a little and push out a portion (actually by little explosion and expansion) of the sand, which has now become dry, into the mould space through the molten iron. This penetration is rapidly repeated so long as the metal remains in a liquid state or the gases cannot escape, by which time quite a rough lump, or lumps, are left on the casting. During the time the scabbing is taking place, the gases are following the line of least resistance by passing through the molten iron into the runner gates and risers, with a series of puffs when escaping.

The sand thus removed from the mould forming the scabs, usually finds its way up through the molten iron, and makes dirty, unsightly holes in the casting.

Scabs may again be referred to, but although the conditions are different, the origin is practically the same. No amount of venting will prevent a wet mould from scabbing. It may be minimised, but venting cannot carry the gases off quickly enough.

Moulders have no definite method of determining the suitable amount of moisture for green-sand work, except by the feel in the hand, which method is general. Accuracy comes only by experience, but by such means, with judgment, the moisture can be gauged sufficiently correctly for all practical purposes. Different sands will carry more or less moisture without being harmful. The writer's experience is that even the strongest of red sand, such as Worcester, Mansfield and Worksop districts, will carry as much moisture as the weakest yellow sands from Erith and district without being harmful. Erith weak sand is probably the finest grain of moulding sand procurable; the grains are so small when dry that they resemble fine powder, and give a velvet finish to the mould. It will be noted by the analysis given later that the Erith yellow sands are higher in clay constituent than the Notts red sands. So far from observation, the writer has concluded that the higher the clay constituent the lower must be the moisture, and *vice versa*. Approximately the moisture allowable for green-sand work is 5 per cent. The sand should be only moist enough for the grains to adhere to each other, and remain in bond when pressed together.

Generally, weak or medium sand is the most suitable for green-sand work; the use of either will to some extent depend upon the thickness of the casting. Refractoriness, porosity, bond and plasticity are the principal properties required in a good moulding sand. Approximately, for light castings of 1 in. thickness and under, a weak loam, still further weakened by the addition of floor sand, would be suitable for facing, and so on, the thicker the casting, the stronger the facing sand required.

Dry-sand moulds, of course, contain no moisture when they are poured, and when such a mould is being made the sand can without fear of any harm being done contain more moisture than when moulding in green sand. In fact, it is an advantage to have the sand rather more moist for a dry-sand mould; but there is a limit that must not be passed, for, since all the moisture is driven out of the mould during baking, if the sand is excessively wet, or the water brush is too freely used, the mould when dried will be full of cracks, and possibly when the casting is stripped it will not be exactly the correct size, both occurrences being very undesirable. Very strong sand would also produce these evils, and as both light and heavy castings are made in dry sand, it is difficult to give a quality of sand that would be suitable for all. As before stated, thickness, temperature of pouring, and depth of casting must be considered.

A weak, medium, or strong sand, by being milled in a roller mill, if in a moist condition containing not more than 4 to 5 per cent. water, would greatly increase in bond, and to some degree the increase in bond would be according to the length of time in the mill without the addition of more water. Of course, the sand can be entirely spoilt and quite unfit for moulding purposes if allowed to remain in the mill too long; the sand would be so close and clayey that air could not pass through when rammed, so it is fairly clear that there are several ways of weakening and strengthening the sands by mixing and milling to suit any class of work. On the other hand, if the mill is charged with a sharp sand only, it may grind away the whole day with or without water, but will acquire neither bond or plasticity. Where there is no clay, there is no bond or plasticity.

The preparation of loam for loam moulds made with brickwork somewhat varies. As before stated, loam is moulding sand ground with water, with the addition of porous material for ventilation.

If the loam be required for bricking only, it may be coarse and porous, but if required for finishing—

that is, the last striking and finishing course—it must be finely ground with manure for porosity and cow hair for cohesion, the whole being thoroughly ground in together. The consistency of loam according to requirements may vary from a thin slurry to a stiffness that allows chopping with a shovel. The strength of the loam will correspondingly depend upon the strength of the sand charged. If the sand in stock is too strong, some old floor or par-burnt coro sand may be added to weaken it. If the stock sand is too weak for the loam required, clay may be added to increase its strength. The terms "weak," "medium," and "strong" in reference to sand or loam indicate the high or low percentage of clay constituent.

Dry sand and loam cores are baked, hence they are both dry sand, but there must be a distinction made between the two, as the preparation and kind of sand is widely different. In foundry parlance, a loam core is understood to be made of wet ground loam of a consistency soft or stiff. A dry-sand core is understood to be made with various kinds of sand and compositions that may or may not have been milled, with sufficient water to moisten. Accordingly the chief difference between a dry-sand core and a loam core is the quantity of water used in preparation, although otherwise the methods of making these cores are quite different. Hence a loam core is a dry-sand core, but a dry-sand core is not a loam core.

Dry-sand cores are made in many qualities of sand and other ingredients, such as a mixture of sharp sand, flour, oils, etc., but these are on the small side, and such cores do not endure heavy bodies of hot iron around them without fusing, either in part or wholly. One of the strongest and hardest binders for small cores is gas tar from producer-gas mains. When the cores are dipped in this liquid and dried, they are as hard as a stone, and a hammer would be required to break them; but as a binder gas tar is objectionable on account of the gases given off when in contact with the molten metal.

Gum powder in the dry state, or dissolved in hot water, and mixed with core sand, gives a very hard core, and as a binder does not generate so much gas as tar, except with machine-made and small cores. The writer has not had occasion to resort to artificial binders; the natural bond of the sand, if properly manipulated, has been sufficient.

Large dry-sand cores often have mixed with them manure, peat, sawdust, chaff, etc., for porosity. These materials also assist in cleaning out the cores more easily. Molasses is a very effective binder for small cores. At the present time there are on the market and in use, mechanical sand mixers which should considerably reduce the enormous waste of good and useful sand.

## Analyses of Sand.

*Yellow Moulding Sands Quarried at Erith, Kent.*

| | Strong. Per cent. | Medium. Per cent. | Weak. Per cent. |
|---|---|---|---|
| Silica ... ... ... | 80.50 | 83.10 | 88.30 |
| Alumina ... ... ... | 11.00 | 9.80 | 7.69 |
| Ferric-oxide ... ... | 3.20 | 2.70 | 2.54 |
| Lime... ... ... ... | 1.20 | 1.04 | 0.72 |
| Magnesia ... ... ... | 1.08 | 0.71 | 0.58 |
| Loss on ignition ... ... | 2.38 | 2.03 | 0.92 |
| | 99.36 | 99.38 | 100.75 |

*Red Moulding Sands Quarried at Warsop, Notts.*

| | Strong. Per cent. | Medium. Per cent. | Weak. Per cent. |
|---|---|---|---|
| Silica ... ... ... ... | 78.70 | 81.90 | 85.30 |
| Alumina ... ... ... | 7.87 | 6.03 | 5.56 |
| Ferric-oxide ... ... | 2.23 | 2.34 | 2.57 |
| Lime ... ... ... ... | 2.70 | 0.40 | 0.30 |
| Magnesia... ... ... | 1.73 | 1.24 | 0.46 |
| Loss in calcination ... | 5.05 | 1.84 | 1.62 |

*Erith Sand,—Analysis on Sample dried at 212 deg. Fahr.*

| | Per cent. |
|---|---|
| Silica ... ... ... ... ... ... ... ... | 86.30 |
| Alumina ... ... ... ... ... ... ... | 6.37 |
| Iron oxide ... ... ... ... ... ... ... | 2.53 |
| Lime ... ... ... ... ... ... ... ... | 1.00 |
| Magnesia ... ... ... ... ... ... ... | 0.90 |
| Loss on ignition ... ... ... ... ... ... | 2.25 |

Sand contained 8.62 per cent. water before drying.

*Strong Red Moulding Sand from Worksop.*

| | Per cent. |
|---|---|
| Silica ... ... ... ... ... ... ... ... | 76.86 |
| Alumina ... ... ... ... ... ... ... | 8.58 |
| Lime ... ... ... ... ... ... ... ... | 3.28 |
| Magnesia ... ... ... ... ... ... ... | 0.36 |
| Oxide of iron ... ... ... ... ... ... | 2.50 |
| Water... ... ... | |
| Organic matter ... | 6.95 |
| Carbon-dioxide ... | |

The above sands are all suitable for ironfoundry work.

## Melting Points of Sand Constituents.

| | Degrees Fahr. | Degrees Cent. |
|---|---|---|
| Melting point of cast iron ... ... ... about | 2,400 | 1,315 |
| " " silicate of alumina " | 4,350 | 2,386 |
| " " " magnesia " | 3,960 | 2,182 |
| " " " lime " | 3,810 | 2,098 |
| " " " Iron " | 3,270 | 1,797 |
| " " " soda " | 1,500 | 815 |

## Legal Position of Trade Unions.

In the Court of Appeal, on December 1, Lords Justices Vaughan Williams, Buckley, and Kennedy, gave judgment in the case of the Friendly Society of Ironfounders of England, Ireland, and Wales *v.* Ingall, on the appeal of the defendant from a judgment of the Divisional Court (Mr. Justice Phillimore and Mr. Justice Bankes) reversing a decision of the Judge of the Sheffield County Court. In the action the plaintiff Society claimed the repayment of £100 given to defendant as compensation following an accident. Defendant had signed an agreement to return the money in the event of his being able to resume work, as he did. The County Court Judge held that the action was not maintainable, but the Divisional Court entered judgment for the plaintiffs.

Lord Justice Vaughan Williams, in his judgment, said it was admitted that this case was covered by the decision of the Court of Appeal in Russell v. the Amalgamated Society of Carpenters and Joiners, and that, therefore, it could not be contended that the plaintiff Society was a lawful association at common law. That did not affect the right of the Society to raise the point hereafter in the House of Lords. If the agreement sued upon fell within Section 4 of the Trade Union Act, 1871, the action was not maintainable. By that section it was enacted that nothing in the Act shall enable any Court to entertain any legal proceeding instituted with the object of directly enforcing (1) any agreement between members of a trade union concerning the conditions on which any member shall be employed; (2) any agreement for the payment by any person of any penalty to a trade union; (3) any agreement for the application of the funds of a trade union to provide benefits to members. In his opinion, the whole agreement fell with Sub-Section 3 of Section 4, and therefore the action could not be maintained. The appeal must consequently be allowed.

In consequence of the new appointment of Professor A. McWilliam, of Sheffield, the Sheffield Society of Engineers and Metallurgists will lose the services of its secretary. Mr. F. K. Knowles, who has held the office for the past 20 years, is on the staff of the Applied Science Department of the University, and, in consequence of Professor McWilliam's removal, he and Mr. F. Ibbotson are to be appointed senior metallurgical lecturers. In view of his increased duties, Mr. Knowles has resigned the secretaryship of the Society.

# Some Practical Problems of the Foundry.

The Birmingham Branch of the British Foundrymen's Association devoted the third evening of the present session to a discussion of a number of questions of practice incidental to foundry work and difficulties which had arisen in the experience of the members. The subjects set down for discussion were (1) Cavities, shots and blowholes in iron castings; (2) Drop-bottom *v.* solid-bottom cupolas; and (3) The best metal and design for annealing pans. The President of the Branch, Mr. H. L. Reason, was in the chair.

### Cavities, Shots and Blowholes.

The PRESIDENT requested Mr. C. Heggie to open the discussion on "Cavities, Shots and Blowholes." He thought they would agree with him that these defects might be called the ghosts of the iron foundry.

MR. C. HEGGIE said he, at the request of the Committee, based his remarks largely upon the report of Mr. Thomas D. West, presented before the American Foundrymen's Convention at Pittsburg in May, 1911. The principal portions of this report appeared in the FOUNDRY TRADE JOURNAL of June, 1911, and the attention of the members of the Branch had been directed to it in the notice convening the meeting. Mr. Heggie said that Mr. West had made rather an extensive investigation. Information, opinions and specimens of castings containing the defects mentoned, were invited by Mr. West from his brother foundrymen, and in this way some useful knowledge was gained. One of Mr. West's correspondents conceived the idea of making iron shot in the hope that if they could produce the shot they would also be able to prevent the recurrence of the trouble. The chemist of this firm stated that the iron spilled in the foundry when charged in the cupola trickled down through the charge, and being insufficiently melted became mixed with the molten metal, thus forming shot in the casting. The firm, therefore, placed some of these chilled particles in a ladle with molten iron, and poured a number of moulds, but were unable to find any shot in the castings. After having tried placing rattling stars, small set screws and pieces of steel in both the ladle and in the mould, and pouring iron over them without any shot being produced, they tried wetting the gate of a mould to make it blow, but without any result in the shape of shot. Whilst the damp, hard sand caused blowholes, it did not produce shot. In fact, they were unable to produce shot under any conditions. They therefore reached the conclusion that shot was formed by something in the iron mixture. Another foundryman suspected that the shot might be caused by the hard stars used for cleaning castings, but after exercising care to prevent the possibility of the stars getting into the scrap the trouble still continued. The general trend of the various experiences reported in these communications would indicate that the introduction of small chilled particles into the cupola was not responsible for the formation of shot. He (Mr. Heggie) thought most of those present had come to the same conclusion. They did not expect shot to be caused in that way. One of the correspondents forwarded to Mr. West a sample containing a small button or shot loosely embedded in the drag side of the casting. The interesting point of this specimen was that a small hole was shown just above the chilled shot and extending through the ½-in. thick metal. It was evident, Mr. West said, that as the shot was formed on the lower surface of the casting, gas was generated which escaped through the cope, but not sufficiently fast to prevent the formation of the blowhole. It was unfortunate that this sample of hard shot was too small to afford sufficient material for a complete analysis, which would have materially aided in the solution of the problem. It was possible, said Mr. Heggie, that a small piece of chilled metal might have been embedded in the face of the mould, but that sort of thing, of course, should not happen. With regard to the analysis, he did not see how it would help very much if they got an analysis of the chilled metal. No doubt the chilled metal was the result of the blowhole, but he did not see how the latter could be accounted for by an analysis of the former. Another specimen received by Mr. West showed a cavity with globules of iron suspended from the roof of it, and this, in Mr. West's opinion, was caused by defective ramming, gating, or pouring of the mould. Mr. West suggested that the gases causing these cavities might originate during the filling of the mould, or not until some time after the mould had been poured, and before the metal had solidified. These gases, it was thought, formed a cavity in the metal through the top of which small drops of still partially liquid metal might ooze, and thus form shot or suspended globules. In a Paper read before the British Foundrymen's Association by one of their own members, Mr. P. Munnoch, at the annual Convention held at Newcastle, in 1908, some valuable information was given. Mr. Munnoch, in writing to Mr. West, said: "My first experience was with grey shot enclosed in small castings, which, on account of their size, yielded only sufficient material for partial analysis, and therefore were very little different from the casting from which they were obtained. In some cases this shot originated from splashes of metal in the mould produced while pouring. Some large buttons, later obtained, were not caused by splashes, but must have liquidated from the casting after the greater part of the metal had solidified. The analyses of these buttons were similar to those obtained from phosphoric pig-iron. After the metal had solidified, it was subjected to hydraulic pressure, and when the results of early experiments were submitted to Mr. J. E. Stead, he expressed the opinion that the blowholes were first formed, and later became filled with a highly phosphoric liquate. Examinations of castings received from various sources showed that all suffered from this defect to a more or less extent." In reference to some shots obtained from castings of large blowing cylinder heads weighing about 10 tons, Mr. Munnoch said that some specimens several ounces in weight were obtained, and that in some cases buttons of different composition were obtained from different parts of the same casting, and pieces of different composition were obtained from the same cavity. These castings varied in thickness considerably, and the moulds were built up largely of cores, some of which were difficult to vent. The castings were square with a circular web and flange extending round the top, and the holes were formed in the top flange, and were only revealed after a considerable thickness of metal had been machined off. The holes were large, and their surfaces were smooth and bright, while in one or two cases oxide was found. The upper surfaces were also smooth with rounded projecting crystals, indicating the rising of gases after a considerable thickness of metal had set at the top of the mould. The lower parts of the cavities indicated shrinkage in places, but the bottoms were usually covered with the liquidated masses. Mr.

Munnoch added, "Generally the formation of blowholes and shot are noted particularly in iron that has been oxidised in melting, instances of which can be noted when the first metal from the cupola runs cold, particularly when soft iron is being melted. If this is caught in a ladle and allowed to solidify, it often presents the appearance of a spongy mass full of shot, the holes and shot being coated with oxide and graphite. If some of this metal is left in the bottom of the ladle and hot, fluid iron is poured over it, a boiling action follows, and if poured into the moulds the castings produced will contain numerous holes of the shot-hole type. Holes of this kind may be either bright or tinted inside, and usually contain graphite and particles of oxide in their lower portions. Mr. West gave a sample showing shots and blows caused by improper gating, and stated that after an investigation, the conclusion was reached that the trouble was due entirely to the method of gating, which permitted the metal to rush into the green-sand mould and impinge on a wall of sand, which, until the depth of the metal in the mould had reached the level of the gate, and thereby retarded its cutting action, scattered the iron in all directions in the form of shot. This was mixed with dross and dirt cut away from the mould, and was carried out on the rising surface of the metal, and was ultimately deposited in some horizontal plane of the casing. This, Mr. Heggie remarked, must indeed have been a "waster." He had known a case very much like this; the cause, however, was not in the gating, but in the actual pouring. When the pouring started, spots or splashes of metal were allowed to enter the mould, and being chilled, were never properly remelted, the casting being a light one. The hard spots could not be seen, and were not discovered until the casting was being machined. Mr. Munnoch, in his Paper at Newcastle, said: "Holes classified as blowholes generally include holes formed by air, gas, or steam from mould or cores, air drawn down runners and forced through the metal in the mould, also gases due to oxides of iron and manganese reacting on the carbon in the solidifying metal, or on graphite already separated, or on the carbon or graphite of the moulds. Sulphur is also an indirect cause of these troubles, due to the formation of manganese oxide from sulphide of manganese." Two rather interesting samples of white iron embedded in grey iron were given by Mr. West, who offered no explanation. This occurrence Mr. Heggie thought was comparatively rare. He had seen it once, and once only. The casting was 3/16 in. thick, and the chilled or white iron was 3/64 in. thick, extending nearly the whole length. In conclusion, he would say that from what they could gather, cavities, shots and blowholes might arise from any of the following causes:—Mould too hard, imperfectly gated or vented, or too wet; cores insufficiently vented; improperly poured mould; composition of the metal; metal not melted hot enough or cast too dull.

Mr. J. W. Sleigh recalled the fact that Professor Carpenter had stated that he had found a considerable quantity of dissolved gases in metals. The gas found by Professor Carpenter the speaker understood to be nitrogen, but he was not quite sure. He (Mr. Sleigh) did not know much about cast-iron, but as far as other metals were concerned he had had a great deal of experience, especially with aluminium. He knew that aluminium could be cast best out of a covered pot. If they poured from an open pot they were very likely to get the metal full of blowholes, but blowholes of altogether a different character from those which had been described, the largest being about the size of a pinhead. They would often find in the circumstances he had described about a hundred in one casting. In manganese bronze they also got blowholes of a similar character. They sometimes got them in low-quality brass. They also got them in alloys containing nickel. It was a very difficult matter to get a really sound casting where there was nickel present. Some casters seemed to have hit on the way of doing it, but they kept the secret to themselves and he had no idea how they did it. The average casting was almost sure to have some blowholes, and a large casting was usually full of them. The reason for that was that the gas got into the metal out of the furnace, as was proved by the fact that pouring from a covered pot, if it did not cure it, would make it better. About twelve months ago they were casting at his place some very high-grade malleable iron castings to stand a very severe test. The castings when broken were full of little blowholes. Their manager, who was a brass-founder of experience, but had had no experience with iron castings, suggested that they should cover the pot. (They did not melt the iron in a cupola.) The result was that they got rid of most of the blowholes though they did not disappear altogether. Since then they had always covered the pots when making malleable-iron castings. Therefore he suggested that all blowholes were caused by dissolved gases out of the furnace. When working with a cupola they could not avoid that. Shots did not occur in brass as a rule. He had seen three in a brass casting. He saw only on the previous day a round rod about 6 in. long and about 1 in. in diameter with a hole straight down the centre. The rod was cast in low quality brass, and the hole down the centre was about ¼th in. in diameter and extended nearly the full length of the rod. He attributed that to two causes, shrinkage and gas. The zinc would shrink 5/16ths while the copper would shrink less than 3/16ths to the foot, so that when the mixture contained a great deal of zinc it was sure to give way. As they knew there was no actual compound then in solution, and one metal shrinking against the other would cause this hollow in the centre. In an iron casting, of course, they would not have this trouble, and he thought that the gases from the furnace had more to do with the trouble than some of them might think.

Mr. J. Peers thought that the trouble from shots and cavities arose from two sources, gases, and defective gating. If they had a deep mou'd it took some time to get the whole of the metal in, and by the time the metal got to the top it had acquired such a consistency as to keep the gases in, and thus blowholes were formed. His idea of the formation of shots was that by having only a top gate any splashes that were made in pouring hardened on the bottom surface, and that these shots gave off gas.

Mr. J. J. Howell said that some foundrymen thought that the shots were formed first. Personally he did not. He thought that the cavity was formed first, and that it was due to occluded gases, although the shots on analysis varied considerably in constitution. Mr. Munnoch and Dr. Stead had stated that they were formed from an eutectic mixture. If that were so it proved conclusively that the cavity was formed first because they knew that the phosphite eutectic was a compound containing 6.7 per cent. of phosphorus and 2 per cent. carbon, so that the mass of iron was a pasty mass while the phosphide eutectic was still liquid. The metal in its crystalline state came across these cavities and the metal found there was extracted from that fluid. He was in full accord with Mr. Munnoch in saying that these shots were due to the phosphide eutectic, athough two shots which he (Mr. Howell) had analysed, shots which he had found in these cavities, did not agree with the phosphide eutectic theory. One contained 2.7 per cent. of phosphorus, and the other 4.5 per cent. The shot which contained 2.7 per cent. showed under

the microscope an eutectic structure. He did not know why, but the fact remained that the shot which contained the lowest phosphorus gave the best eutectic character. In some cases he through the trouble was due to occluded gases, whether from steam or from hydrocarbons he could not say; but he felt positive that that poor old bugbear, sulphur, was not the culprit. He followed Stead's method of making photographs, and he rarely found any trace of sulphur in the cavities which he photographed. That seemed to him to point to the trouble being due either to hydrocarbons or, as had been suggested, to nitrogen. As to which of the two was the explanation it was difficult at present to make a definite statement, but there were a number of clever men at work on the problem, and, perhaps, before long, they would get a positive statement as to what the cause was, and then they would, perhaps, find a means of preventing the formation of cavities.

Mr. J. Peers said that where they got shots in the cavities it was due to a deficiency of runners. When they had top gate runners and allowed the metals to run in from the top so that they got the metal off on the top surface, and allowed the gases to escape, they got rid of the shots and the cavities. He believed that was a step towards the solution of the problem.

Mr. Dobson said that if they got the metal of the right composition they got very few blowholes. He thought the only successful way to cast was from a live centre.

Mr. G. Hailstone remarked that it should have been explained what was a cavity and what was a blowhole in a casting. In casting iron at different temperatures they could get blowholes, and then a solid casting, and then blowholes again, *i.e.*, spaces which looked like blowholes—round holes in the castings, through pouring at different temperatures out of the same ladle. They could also get shrinkage holes, which were produced by liquid contraction. He did not propose, at the moment, to speak about liquid contraction in cast-iron. In the first place one could cast a grey iron casting with 0.2 per cent. of sulphur perfectly sound with no blowholes in it, at a certain temperature. If the same iron were cast at a lower temperature it would be full of blowholes. He remembered some years ago using a certain brand of coke in the cupola one day, and when the castings were examined next morning it was found that the majority of the thin castings which had thick portions on them, were drawn. He analysed the metal and examined it microscopically and found it up to specification. A few days afterwards that same coke was used again, and they had the same difficulty with drawn castings. The next day the ordinary coke was used and the castings came out perfectly sound and without any drawing. It was evident, therefore, that besides the gases and the temperature of pouring the venting and so on, it was necessary to consider the materials they were using. With regard to cavities, they had been taking them, in that discussion, all as cavities, but there were at least a dozen different kinds of cavities formed in different ways. With regard to the influence of gases on cast-iron he might say that the higher the temperature the iron was brought to in melting, the larger was the amount of gas which the iron would dissolve, and the higher the temperature at which the iron was cast the more solid would be the iron. If the iron were left to cool down in the ladle there was time for these gases to separate out and consequently blowholes were got; if the metal were cast hot blowholes were not formed because there was no time for the gas to separate out.

Mr. Heggie, in reply to Mr. Hailstone, said that the reason he did not refer to draw holes, or shrinkage holes as they called them, was that it was understood that the cavities they were referring to were blowholes. Of course, as practical foundrymen, they would not mix the two things up, and he understood that in that discussion they were really dealing with the cavities due to blowholes. As a general rule he had not much fear of gases in the metal causing blowholes. He believed it was something in the actual moulding which caused them. If they got good results from their usual iron, melted in the usual way, and then found that they got blowholes in a casting it was evidently due to something in the mould. They got blowholes if they tried to save coke. But if they got their iron hot enough the greater affinity of the manganese and silicon for the oxygen would prevent the formation of iron oxide.

Mr. Peers said that with thin casting they could pour the metal from the top and get the castings solid, but with a large casting it was a different matter altogether. It was because they did not arrange the runners properly that they got casting cavities. He believed that what Mr. West referred to were large castings, because if they splashed a drop of metal in the gate a shot would be formed.

Mr. Hailstone: I think there are a good many eminent foundrymen in this country who will bear me out when I say that the larger the casting you have and the higher the temperature at which you pour it the more solid that casting will be.

Mr. Peers: I did not mention the temperature. I was not thinking about the temperature. I was only speaking of the way of pouring.

[Note.—Owing to considerations of space, the discussions on cupolas and annealing pans must be held over until the next issue.]

## Association Technique de Fonderie.

The Committee of the Association Technique de Fonderie met recently in Paris. After acknowledging various donations, the Committee decided to make a fresh appeal to the large iron and steel companies, founders, and engineers in favour of the exercise of their generosity by making grants which would permit of increasing the sphere of activity of the Association. It was also resolved to allocate the sum of £40 to the establishment of two prizes of £20 each, which are to be awarded in connection with the 1912 competitions. The first meeting in 1912 was fixed for March, and will coincide with the general conference of the Fondeurs en Fer en France, and the second will be held at the end of the year, when the competitive memoirs, among others, will be considered and discussed. The first prize of £20 is to be awarded for a memoir dealing with a practical study of the foundry cupola, and the second for a memoir examining the small phenomena which take place in moulds. All practical and technical foundrymen, whether French or of other nationality, and whether members or non-members of the Association, are able to participate in the competitions. The memoirs are to be written in French, and are to be addressed to M. Barthe, President of the Association, 43, Rue de Clichy, Paris, before April 30, 1912.

On Friday, December 8, at the Northampton Polytechnic Institute, Clerkenwell, London, E.C., the annual prize distribution and students conversazione was held, when Sir William H. White, K.C.B., LL.D., D.Sc., F.R.S., late Chief Constructor to the Admiralty, distributed the prizes and certificates. A good musical programme was provided, and on the next evening, December 9, the building was thrown open to the whole of the members and students and their friends

# Foundry Metallography.

By J. S. Glen Primrose.

The monthly meeting of the Scottish Branch of the British Foundrymen's Association was held on Saturday afternoon, 9th December, in the Glasgow Technical College, the Branch Vice-President (Mr. W. Mayer, of Dumbarton) occupying the chair. The lecturer (Mr. J. S. Glen Primrose, A.G.T.C.), who read a Paper on "Foundry Metallography," showed the increasing value of the microscopical method of examining the structure and keeping a check upon the standard of pig-irons and foundry castings. By the aid of numerous lantern slides Mr. Primrose showed the modifications of equipment necessary and the method of applying the tests in a practical manner, also showing the typical structures of various varieties of cast-irons and how these were affected by the alteration of the percentage of added elements and by different heat treatment. Definite values were assigned to each of the elements commonly present in cast-iron, but the rate of cooling was shown to influence the structure in an even more remarkable degree than the combined metalloids. The harmful effects of phosphide and sulphide segregations were fully commented upon and illustrated by photo-micrographs, and the various suggestions which have been made to improve the quality of cast metal as controlled by its structure were closely investigated. The great value of the microscope as an aid to the investigation of failures and wasters was pointed out, and several examples coming under the notice of the author were quoted to show the direction in which the remedy was to be sought.

Fig. 1.—Phosphoric Pig-iron, Slowly Cooled; Mag.: 90 Dia.

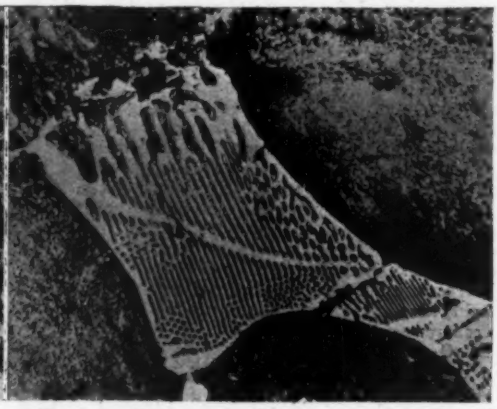


Fig. 2.—Phosphide Segregation in Fig. 1; Mag.: 240 Dia.

Whilst the saturation point of molten iron for carbon has been usually taken to be about 6.7 per cent., a micrograph was shown of a grey iron containing only 0.31 per cent. of silicon, which when cast from an electric reduction furnace was found to contain 7.52 per cent. of carbon; only 0.93 per cent., however, remaining combined as the carbide after solidification. Recent work has shown that at about 2,200 degrees Centigrade molten iron is capable of dissolving about 9.7 per cent. of carbon. As showing the effect of slow cooling on an ordinary phosphoric iron, Figs. 1 and 2 are reproduced. These clearly indicate the powerful

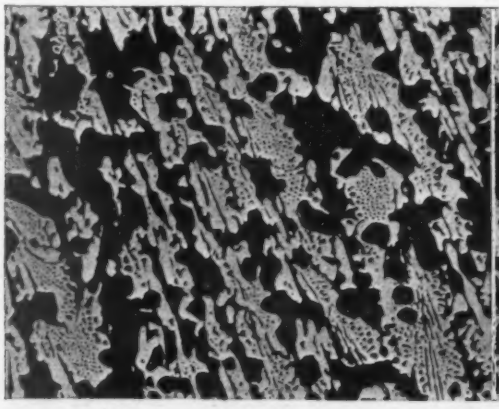


Fig. 3.—White Cementite Edge of Chilled Grey Iron; Mag.: 90 Dia.

Fig. 4.—Graphite in Interior of Chilled Grey Iron; Unetched.

effect of the silicon in throwing out the graphite in large flakes, and the beautifully laminated structure assumed by the phosphide segregations, which are, of course, very brittle. Figs. 3 and 4 were to demonstrate the effect of casting even a very grey pig-iron in metal moulds, as is done in America. The edge is seen to be very largely composed of cementite, produced by the chilling effect, whereas the centre shows quite large flakes of graphite, these beginning to appear within a comparatively short distance from the edge.

the effect of almost completely eliminating the graphite, unless with excessively slow cooling. Figs 5 and 6 show micrographs of these two types of structure as found in Canadian pig-irons.

The most recent method of reducing the size of the graphite flakes has been by the use of varying proportions of steel scrap, which not only makes the combined carbon solidify in a very close-grain variety, but also helps to keep the phosphide segregations from assuming weakening proportions. Figs. 7 and 8 illustrate a mixture of ordinary hard iron with 15 per cent.

FIG. 5.—HIGHLY NICKELIFEROUS PIG-IRON (NICKEL 18.5 PER CENT.), UNETCHED; MAG.: 60 DIA.

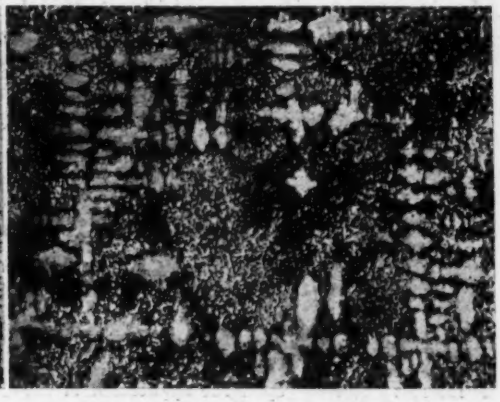


FIG. 6.—SIX PER CENT. NICKEL PIG-IRON; MAG.: 60 DIA.

As the effect of chilling is usually too severe on an ordinary casting, other methods have frequently been tried to get the separation of small flakes of graphite, and illustrations were given to show the effect produced in fining the grain by the addition of small quantities of aluminium. Physical means have also been tried, as in the Custer method of casting with permanent moulds, in which the separation of graphite is supposed to take place only after the metal has

of steel scrap; these explain why the material showed very good results on testing, viz.: 17¼ tons tensile strength and 30 cwts. transverse.

In the production of malleable castings, the rate and duration of heating were shown to have a similar well-marked effect on the size and arrangement of the separated carbon, which, being produced from the decomposition of the cementite, occurs in the amorphous state, and not like graphite, in flakes. The slower and

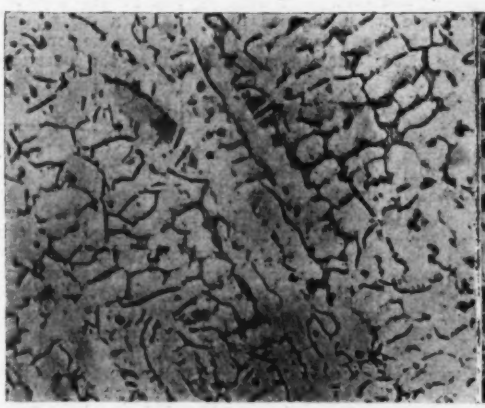


FIG. 7.—STRONG SEMI-STEEL (UNETCHED); MAG.: 90 DIA.

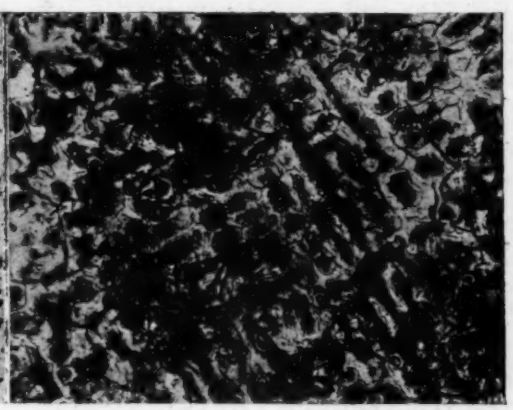


FIG. 8.—STRONG SEMI-STEEL (ETCHED); MAG.: 90 DIA.

become solid, and therefore only small flakes are possible. The addition of nickel, as found naturally in some Canadian pig-irons, was described as producing the formation of very curly, and therefore strong, graphite flakes, but only when present in comparatively large quantities; whereas about 5 per cent. has

more prolonged heating in the production of Reaumur iron, in which case much of the carbon originally present has been absorbed by the packing material, the carbon shows very minute and even distribution. In the American "Blackheart" iron, however, the heating is more rapid and for a shorter period, with

the result that the amorphous carbon is seen in comparatively large patches in the ground-mass of iron, and the combined carbon left is very irregularly arranged. This is well shown in the two photo-micrographs, Figs. 9 and 10.

A short discussion followed, in which points of practical interest bearing upon the application of the microscope were raised and answered. The lecturer pointed out the difficulty involved in showing isolated portions of the metal sections, and expressed the hope that it might soon be feasible to show cinematograph micrographs of large sections moved across the field of view.

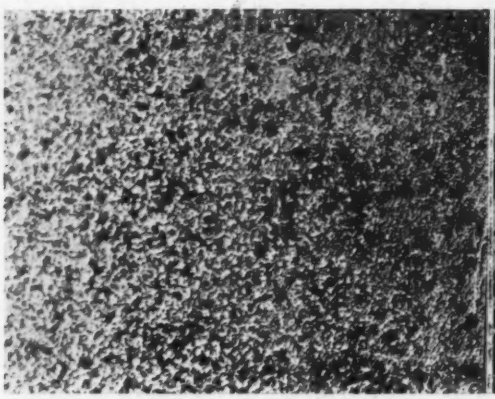


FIG. 9.—REAUMUR MALLEABLE CAST IRON; MAG.: 30 DIA.

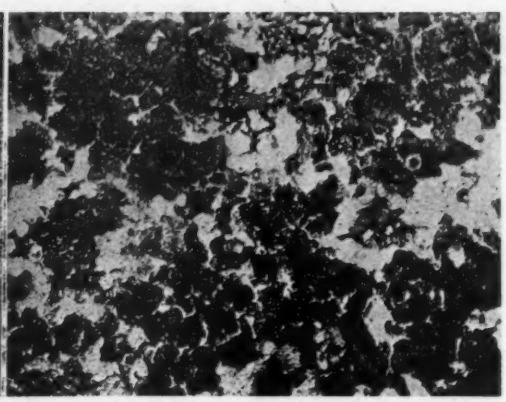


FIG. 10.—AMERICAN BLACK-HEART MALLEABLE IRON; MAG.: 30 DIA.

# Elementary Remarks upon Loam and Sand Moulding.

When making a casting in loam, whether it be large or small, plain or difficult, the preparation of the tackle is most important, and if the casting is a difficult or intricate one to mould, there is more reason for forethought, as it is at this point where the ingenuity of the pattern-maker and moulder needs to be displayed.

The work is laid out full size, or as far as is necessary, in the pattern shop, and the moulder with the aid of the pattern-maker gets the dimensions for his tackle from it. The important points the moulder must watch in this matter (apart from correctness of sizes) are, first, that the tackle is strong enough; second, that provision is made for runner gates and risers, bolting up, and escape of air; third, that provision be made for easing or liberating after pouring, and for the contraction of the casting. Where more than one casting is required, when practicable, the tackle should be so made that it will carry the work through. It is by considering these points, which often demand much foresight on the part of both moulder and pattern-maker, coupled with good methods of moulding, that much time and expense are either lost or saved.

It is far preferable (within reason) for a moulder to err on the heavy than on the light side when making his tackle, because the breaking or snapping of a plate, binder, staple or bolt often means commencing afresh, besides the possibilities of injuries to those about the work.

All cake-plates should be regularly prodded, and an abundance of vent-holes cast in by means of pieces of core, coke, etc., but not to the extent that the plates will be unduly weakened, or rendered liable to fracture when exposed to heat, as in drying, after pouring, etc. The holes not only provide for the escape of air, but also assist in holding the loam to the plates.

### Bricking and Binding.

The stability of loam moulds where much walling is required depends upon how the brickwork is done. Especially is this so where great length or depth of brickwork exists, either with moulds or cores. The writer has seen moulds and cores collapse before stoving, simply from improper bricking. There are other evil results from faulty brickwork, such as swells and irregularities. The bricking should be done in such a manner that as far as possible the bricks should bind and support each other. As the brickwork is proceeding, each joint should be covered by the next course of bricks, and binders put on at intervals. These are necessary to support and keep the brickwork intact during slinging, drying, etc. For instance, if a core or mould be 9 ft. to 12 ft. long, at least two or three binders should be used to make a safe mould or core; they add stability and resist deformation.

The loam for bricking should neither be stiff nor sloppy, but should be of a medium consistency, with plenty of opening material in it, such as manure, shredded peat, long chaff, or chopped straw. The opening material not only assists in bringing away the air, but also by its openness assists in drying. If sloppy loam is used in bricking, the mould will as-

sume any shape or form. If very stiff loam is used the bricks will not bed aright; consequently, uneven walling will be the result.

### Venting.

The generation and expansion of gases during the pouring of a casting makes it necessary that channels be provided for their rapid escape, and various means are adopted to accomplish this. For example, where a flat, or nearly flat, surface forms part of the mould upon which liquid metal has to rest or pass over, the bricks should be kept from ¼-in. to 1-in. apart with no loam between them, the open spaces being filled in with ashes or cinders to the level of the bricks. In all cases of bricking the allowance for loam between the brickwork and the striking board should be about ¾ of an inch; the opening material that is in the striking or finishing loam then allows the air to pass through to the cinders, preventing scabbing. Escape from the cinders is also provided by thin layers of straw laid on the bottom plate before the loam is put on for the first layer of bricks. Also the holes provided in the bottom plate allow the air to escape, and if that provision is not made, escape for the air can be made from the joints of the outside row of bricks (as is sometimes done if the brick mould is rammed with floor sand), by carrying around straw ropes which are finally brought off at intervals through other spaces (See Fig. 1.) It does not matter what means are adopted, providing they are safe and the air can escape quickly enough to prevent scabbing and blowing.

The method of bringing the air away from underneath a flange is shown in Fig. 2, but for conducting air from underneath a top, or intermediate flange, or

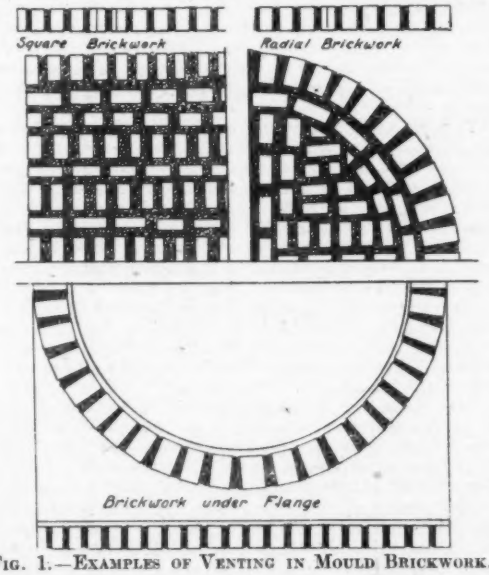



FIG. 1.—EXAMPLES OF VENTING IN MOULD BRICKWORK.

any narrow surface (such as occur in vertically cast flange cylinders) where there is danger of scabbing, it is better to carry a narrow channel formed with stiff loam right around, filled with ½-in. mesh cinders about 1-in. below the surface of the flange and at several places finally bringing the gases off by whisps of straw or small ropes through the joints of the brickwork.

### Dressing, Blacking, etc.

A large loam mould or core should not be checked for sizes when very hot. If dressed in that state, and probably not cast till only warm, the sizes of the casting will not be accurate, unless the moulder is very fortunate in gauging how much the mould or core will contract from the time the sizes are checked to the time the casting is poured. If the mould or core is dressed and checked with callipers when very hot, it will certainly be small when the casting comes out. No reference is now being made to the ordinary contraction of cast iron for which allowance is always made in the size sticks, but to the expanded state of large moulds or cores when very hot, as bricks, loam barrels, binders and plates all expand with heat and contract in cooling.

It is also unwise to blackwash where very hot; the result of so doing often is that the loam cracks, and web markings are developed on the casting which were quite invisible to the eye either on the mould or core. This is quite apart from loam cracks caused by either strong or weak loam. Although the cause of this phenomena is not quite clear, it appears reasonable to suppose that when the blacking wash is applied to the hot loam, steam is generated and penetrates through the thickness of loam to the brickwork, or core barrel, pushing the loam slightly away from the brickwork, thus leaving a small space between. No visible cracks are in the loam, but when the casting is poured the pressure of the fluid iron presses the thickness of loam back against the brickwork, causing small irregular markings, which disfigure the casting when dressed off. This also occurs if the mould or core has had too keen a fire; in this case the bricks, barrel, and loam expand excessively, and when cooling the bricks and barrel contract more than the loam. The loam is often held in this position when left, by its arched shape, which state is precisely the same as that just explained. The cores and moulds when blacked should be just sufficiently warm enough to dry the blacking.

### Different Classes of Moulding.

Green-sand moulding differs so widely in method from loam moulding that there seems little relation between the two except that each method forms a mould of a certain size and shape that will hold molten iron and turn out a satisfactory casting. The instances are not common of individual moulders being capable in both methods of moulding, and this is especially true in high-class engine work. Whichever method a young man adopts or circumstances place him in, he generally follows; hence we have the divisions in the trade of loam moulders, sand moulders, core makers, etc. There are exceptional instances where an individual of wide experience may be efficient at either.

There are many points of difference between the two. A loam moulder's daily routine is with spindles, plates, bricks, straight edges and square, stricking boards, strickles, etc. He has some knowledge of the work in hand from the drawings when the work is laid out in the pattern shop, because, unlike sand moulding, patterns and boxes do not play an important part, excepting as skeleton frames, branches, or some kind of projections. A sand moulder's daily routine is with various kinds of patterns, or in some cases pretensions to patterns, boxes and rammers, etc., to which he has to apply his intelligence as well as weight. A knowledge of drawings is not so necessary for sand moulding as with loam moulding, because as a rule the sand moulder has a complete pattern to work from; but, nevertheless, such knowledge is most useful. A sand moulder, to obtain good results from his work, requires as much intelligence as the loam moulder. The sand moulder's risks in waste or faulty work are also much greater than the loam moulder's.

Apart from the division of loam and sand moulders, there are many other divisions and sub-divisions, such

as chair, plate, grate, oddside, machine and pipe moulders, etc., and such can only work at their respective kinds of work, and are in many cases handy labourers. But the general jobbing moulder is a man who has had experience in different kinds and classes of work, and can in a short time adapt himself to almost any class of work. Of course, due allowance must be made for different methods under which different foundries work. When a sand moulder is working in green sand, he must never forget the moisture in the sand. According to the quality of sand, so should the percentage of water be. A weak sand which is high in silica and low in clayey matter will carry more water than a strong sand containing a high percentage of clayey matter, without doing much harm when the casting is poured. On the other hand, if the sand is too dry it is not workable; it will not hold together, lacking cohesion. Cohesion in a moulding sand is only developed in the presence of moisture, the extent depending upon the amount of water in relation to the percentage of clay in the sand. The point the sand moulder must watch is that he does not make blown or scabbed castings as the result of excess of water in the sand. The green-sand moulder must vent his moulds more thoroughly than a loam mould, or even a dry-sand mould, because in the two latter cases there is no moisture to contend with when the mould is finished.

With the rammer, also, the sand moulder must use care and judgment. If he does not ram his mould sufficiently the casting swells; on the other hand, if he rams too hard the casting scabs. If the pattern is of great depth, he must ram harder at the bottom than the top; if not, the result will be practically the same as those just named. When the sand moulder is ramming either the bottom or top part of a mould where there are projections or lugs of any kind or bodies of sand, these must be supported by means of sprigs, lifters, and iron grid bars; otherwise, the mould will fall to pieces.

The foregoing are a few brief references to some things a sand moulder must not forget. He must be continually on the watch, and the touching of a lifter, the jerk of the crane, the cramping of a box, and many other little things may contribute to spoil his work.

# The Testing of Moulding Sands.

An interesting Paper on the "Testing of Moulding Sands" was given by Mr. Richard Mather, B.Met., London, to the members of the Sheffield Branch of the British Foundrymen's Association, on Saturday December 9. Mr. Herbert Pilkington, M.I.C.E., presided over a large attendance.

Mr. Mather observed that one of the most marked features of the technical side of industry during the last twenty or thirty years had been the rapid introduction of processes for testing the qualities and properties of the materials used. In a modern steelworks, to ensure that the required quality was reached, practically every batch of material received was, as a matter of routine, tested by the most exact methods available. This was almost equally true of every section of the iron trade, except the foundry, and even there the use of exact tests for pig-iron, coke, etc., was growing rapidly. But moulding sand, one of the foundryman's most important materials, had been left almost unaffected by these changes. Yet, after pig-iron, this material was used in larger quantities than any other in most foundries. The utility of a reliable series of tests needed no emphasis among those who recollected that blow-holes, scabs, rough spots, buckles, swells, burnt-on sand, and many another source of wasters and trouble might be caused by bad sand. Natural aqueous deposits were never of quite reliable quality, and in the case of moulding sands the variations were frequently of such a nature as to pass undetected by the old tests. At the same time the old tests had been, and were, useful, and pronouncements based on them were more often right than wrong. But most foundrymen admitted that too often for good practice these tests failed to reveal important facts.

It could not justly be said that the inadequacy of the present methods of testing moulding sands was due entirely to indifference or opposition to new methods among practical foundrymen. Many of them looked with hope to the advent of the chemist with his ultimate analysis of a sand into silica, alumina, combined water, and so on, but now every judicious chemist saw that such a test, though of value in one or two respects, did not yield a reliable indication of the qualities of the sand as a whole. The foundryman's difficulty had been to find satisfactory and reliable new methods to supplement the old, and he had not had here, as in the case of testing iron, the help of the steelworks and blast-furnace people. Nevertheless, though this difficult task was not yet finished, a good deal of preliminary work had been done, and one might agree with Field that while it was not yet practicable to give definite specifications for moulding sands, the day for that might come.

The position had been reached by the work of a large number of investigators, some of them in this country, but even more in America and on the Continent. A good deal of this work came from sources which seemed to have been largely overlooked by foundrymen, who had not given the attention they deserved to the persistent and fruitful researches of clay and pottery workers, soil chemists and economic geologists. That many of the properties of a mould-sand were connected with the quality and amount of its clay content would be admitted by all foundrymen, and they would do well to keep in closer touch with new developments in the theoretical and practical study of clays.

The qualities which affected the value of a sand to a foundryman were fineness, porosity, permeability, bonding power or strength, and refractoriness. The fineness expressed the state of division of the particles of the sand. It depended on (*a*) the sizes of the grains of the quartz, clay, felspar, etc., which composed the sand, and (*b*) the manner and extent of the cohesion of those grains. The latter factor depended largely on the moisture content. Therefore, in order that comparable results might be obtained, the moisture content must be the same in all tests; at the same time the sand must be in such a state that the grains would pass freely through sieves of the appropriate size if that method of testing were chosen. These two conditions could be satisfied either by removing all the moisture, *i.e.*, working on quite dry material, or by adding a very large quantity of water, *i.e.*, having the sand in suspension in water. The former was the commoner method, and for it Scott suggested heating at 120 deg. F. for one hour, or until the sand was perfectly free from

moisture. For the latter method Ries suggested shaking for two hours under standard conditions 50 grains of the sand placed in an 8-oz. bottle, half full of water, the whole being afterwards washed through a set of five sieves in the usual way. The method was attractive in that it ensured that none of the particles should stick together and thus be counted as belonging to sizes larger than their true ones. This, however, might be overcome in the dry method, and as the wet method removed from the quartz grains any coating of clay they might have, it artificially diminished the effective size the grains would have when in ordinary use. Whether this could be avoided by much less drastic shaking, say, for five or fifteen minutes, which might still break down any cohering lumps, could only be determined by careful comparative tests; but unless and until this was established the dry method was preferable.

The lecturer described Scott's dry method, and suggested that as the fineness of the sand which had passed through a sieve was obviously higher than the mesh of the sieve itself, it would probably be better to modify Scott's method by using the mean mesh of the two sieves rather than the mesh of the sieve the sand had passed through, *e.g.*, the weight of sand which had passed through the 20 mesh and was detained by the 40 mesh should be multiplied by 30 and not by 20. Shaw and Le Chatélier, he mentioned, had also modified forms of test.

The porosity of a moulding sand was one of its most important properties, and for a given bulk of sand in any particular condition as regarded packing, represented the amount of space not actually occupied by the sand grains. The porosity depended on (*a*) the sizes of the grains, (*b*) the shapes of the grains, (*c*) the proportion of quartz to clay substance and other minerals, (*d*) the closeness of the packing, and (*e*) the moisture content. In tests of sand intended for some particular purpose, the last two factors could best be disposed of by testing the sand every time in exactly the same condition as regarded ramming and dampness as prevailed in use. For comparative tests of different classes of sand, constancy would be obtained with the most certainty if all moisture were removed from each test sample, but the most suitable conditions for packing could hardly yet be laid down, though there would be little difficulty in fixing after experiment a standard size and form of test piece rammed with a given number of blows of given weight.

Since the porosity was expressed as the percentage of the total volume of the sand which was not actually occupied, it was evident that if all the grains in a sand were spherical and perfectly packed the porosity would be the same whatever the size or sizes might be. But as these two conditions were never fulfilled, the sizes as well as the shapes and packing of the grains affected the porosity. Irregular, angular grains left a larger proportion of pore space than even, rounded grains, because they could not in practice be packed so closely. King, who carried out experiments on ordinary, not moulding, sands, in this direction, reported that while finely-grained sands had a higher porosity than coarse-grained, the minimum porosity was obtained by mixing about equal parts fine and coarse sands. Probably, experiments would show that the first part, at any rate, of this conclusion would need modifying for moulding sands, since the presence of very finely divided and plastic material, clay substance, introduced a factor of a different nature. There was little doubt that an increase of the proportion of clay-substance did, in most moulding sands, lead to a decrease of porosity.

Humphrey's process he considered more reliable than Scott's test. Porosity, he said, could also be calculated from the specific gravity.

A knowledge of the permeability of a sand was usually of even more value than that of the porosity, since the permeability more nearly represented the actual property of a sand by which gases were enabled to pass through it. It might seem that in otherwise similar sands there was possibly constancy in the porosity—fineness factor. But this could be determined only by a series of careful experiments, and until the matter had been settled in such a way it would certainly not be safe to assume such a constancy. In spite of the fact that there was no fixed relation between them, the permeability did, to some extent, depend on the porosity, since for sands of the same fineness the sand would have the greater permeability which had the greater porosity, other things being equal. For sands of the same fineness and porosity, the permeability would decrease with the dryness and lightness of packing. The permeability would also depend on the shape of the grains. The fusibility of a sand also influenced its permeability in the burnt state, since the fusion and running together of the grains was accompanied by a closing of at least the entrance to the pores and prevented the gas passing through from the metal or surface of the mould to the back. The apparatus devised by Saurer appeared to be the most convenient for the determination of permeability.

The ordinary test of bonding strength, which was carried out by squeezing a handful of the sand, noticing how it adhered and how much force was required to break up the ball, had many advantages, but it was not sensitive, and it depended too much on the personal factor to give unvarying results with the same material. Bonding strength depended upon the sizes and shapes of the grains, the amount of bonding substances, the distribution of bonding substances about the grains, and the moisture content and closeness of packing. The amount of clay substance might be tested by rational analysis, which seemed undoubtedly an improvement on the ultimate analysis, by microscopic examination, or by the special methods of Vinsormeau, Ries, Le Chatélier, Lunge, and Bollenbach; and the amount of colloids by Ashley's methods. More direct tests of bonding strength had been suggested by Outerbridge, Le Chatélier, and Atterberg. Refractoriness depended upon the proportions of the various constituents, the size of the grains, and the closeness of packing. It could be tested partially by heating the sand with acid and more fully by chemical analysis, or a heating test with Seger cones, or similar temperature indicators.

What was wanted now, the lecturer concluded, was a thorough scheme very carefully planned and carried out for investigating the reliability and usefulness of the tests with the object of weeding out those which were unnecessary. Possibly, some useful preliminary work could be done, more particularly in determining the accuracy of a test or the relation of one test to another, by the use of artificial mixtures of the materials constituting moulding sand. But, certainly, the final value of any test would have to be worked out alongside the practical use of the sands in the foundry and after full consideration of the results obtained there. Reliability and the needful degree of accuracy should be the essentials required of each test, but the next place, and a very important place in the scale of values, should be given to quickness and simplicity, so that the foundryman should have no unavoidable difficulty in using and understanding the tests of his sands. If and when, satisfactory and complete tests were decided upon and standardised, it would then remain for foundrymen doing the same work under practically the same conditions to find out what results from each test his sand must give if it was to be

suitable for his particular work. When that stage was reached, the foundry industry would be in a position as regarded its sand to say exactly what it needed and to see that it got it.

A further effect of such a system of reliable and standardised tests would be enlargement of the possibility of preparing sands artificially from sharp sand and clay of strong loam, or by mixing two or more kinds of moulding sand.

### Discussion.

The CHAIRMAN observed that his experience of moulding sands was that it was largely in the first instance a geographical question. The method of using sand in America was very different to what it was in this country. Americans were very fond of artificial binders and quartz grains. On the other hand, they were not so fond of built-up moulds as in this country, and could not indeed compete with us in any sense or form. Personally, he should like to know some method of renewing the youth of burnt sand—(laughter)—and he should very much like to have some test which would gauge that more accurately than it was gauged to-day. He agreed that standard tests were very necessary. The British Foundrymen's Association connected themselves with the Standardisation Committee, which had, however, never got near this subject. He regarded it as a very valuable subject of research, as, to a large extent, they were groping very much in the dark yet.

MR. S. G. SMITH said it was rather remarkable how few foundries knew to any extent whatever the composition of the moulding sands. He related an experience he had a few years ago when he approached firm after firm and found they knew nothing about the composition of their moulding sands. Special analyses had to be got out for his benefit. He noticed that in each case the strongest sand contained the largest percentage of alumina. One of the finest binders was gas tar. A green-sand core dipped in gas tar would require a hammer to break it. The bad points were the gases that emanated when the iron came in contact with it. Referring to the question of renovation, he said that if ordinary clay was dried and ground and then mixed with old sand, it would bring it fairly well back to nature, and make it a usable sand. They had proved, to a certain extent that artificial binders were useful, but cost was the important factor.

MR. W. H. HATFIELD thought that the whole question of the study of sand would prove of value more from the standpoint of renovating the sand than from the standpoint of selecting it. The economic aspect was most important, not only in the cost of the volume of sand coming into the works, but the question of tips. He thought the foundrymen knew what they wanted in the way of sand, and, as a rule, got it, and that the utility of that method of investigation would be found in the renovation of sand.

MR. THOMAS FIRTH said his firm were going in for renovating, and were making experiments that no doubt would result in a very big saving.

MR. MATHER, in reply, said that when they had found the best tests would come the time for Mr. Pilkington's renovation. He agreed that both the ultimate and the rational analysis had a certain value, but what he wanted to point out was that they were by no means sufficient in themselves. They told something, but they hardly told the most important things. They could hardly take alumina as an infallible guide, because they could grind old bricks and mix that material with sand, and they would get a fine alumina content, but they would not get a strong sand. Grinding clay to mix with sand was a pretty common method of revivifying, but they did not always get the same result. Before they could go along with perfect safety they needed some test they could use to find out if the sand they had revivified was up to standard. It seemed very likely the strength of sand depended very largely on the amount of colloids that were present in it. That was a matter for chemical tests, and was not a very difficult one. They might find the amount of colloids in the sand were of more importance than the amount of water in clay. If so, they might get so much colloids and grind them into the sand and get satisfactory results, but that was a matter for the future.

A vote of thanks to the lecurer concluded the meeting.

## British Foundrymen's Association.

### Lancashire Branch.

A meeting of the Lancashire Branch was held in the Municipal School of Technology, Manchester, on Saturday afternoon, December 2. Mr. F. Penlington, President of the Branch, occupied the Chair, and there was a large attendance of members.

A Paper on "The Growth of Cast-irons After Repeated Heatings" was read by Professor H. C. H. Carpenter, M.A., Ph.D., of Manchester University. The Paper was illustrated by a number of fine photographs exhibited to show the effects of varying heats upon cast iron, and by diagrams setting forth the percentages of carbon, manganese, silicon, sulphur, and phosphorus in the different specimens. Professor Carpenter is giving the Paper before the London Branch of the Association in the course of the next month, and it will be dealt with more fully in a later issue of the JOURNAL.

MR. R. W. KENYON expressed delight with the lecture, and remarked that Professor Carpenter had afforded another illustration of the often-repeated aphorism, that genius consisted in an infinite capacity for taking pains.

MR. STEWART asked if the iron grew in proportion to the heat applied.

MR. T. W. MARKLAND remarked that the subject was, undoubtedly, a most important one, and as far as engine works were concerned, they would have to go more deeply than they had done into the growth of cast iron in connection with the making of engines. He would like to know the lowest temperature at which iron grew.

MR. BENTLEY remarked that the tendency in the growth of the metal was to bring the carbon to the top, and when treated by steam it became intensely hard.

PROF. CARPENTER said Mr. Stewart asked whether the growth was proportionate in the diametrical direction, and his reply must be that the bars did grow, and in the process of growth they broke. There was the further fact to be noticed, that very often the bar, after it had reached a certain growth, although it did not grow in volume, it contracted in length and increased in width. In answer to Mr. Markland, he was inclined to think it was susceptible at about 360 degrees C. That was very slow, extremely slow, in fact. He did not see any harm in raising the carbon, and if any one was making grey bars, he should recommend them to start with 3 per cent. of carbon. It occurred to him that during the treatment he had described, the change in properties and the hardening would be caused by the conversion which took place in the process, some of the graphite for instance, passing into another state.

# Inventions.

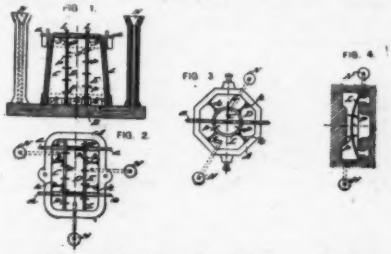
## Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

25,711. Metals or alloys and devices for use with same. R. H. Carpmael.
25,810. Boxes for moulding and casting. W. B. Williams, T. Williams, and B. Rees.
25,890.*Electric furnace. G. Méttler.
25,915.*Process in the refining of iron and steel. K. A. F. Hiorth.
26,034. Refining iron and manufacture of steel. B. W. Head.
26,184. Metallurgical furnaces. V. Stobie.
26,364. Wet sand blast and gas blow-pipes combined. J. Burrows and A. H. Nash.
26,371.*Process for carrying out gas-reactions in an electric furnace. A. Helfenstein.
26,378. Producing bricks and furnace linings of magnesite. O. Frick.
26,379. Re-carburising in electric furnaces. O. Frick.
26,380. Electric arc furnaces. O. Frick.
26,381. Electric reduction of oxides. O. Frick.
26,382. Electric reduction furnaces. O. Frick.
26,414 & 26,415.*Casting apparatus. (Enterprise Manufacturing Company, of Pennsylvania, United States.)
26,416.*Means for discharging sand and castings from flasks for use in casting apparatus. (Enterprise Manufacturing Company, of Pennsylvania, United States.)
26,417. Means for placing weights on moulds, for use in casting apparatus. (Enterprise Manufacturing Company, of Pennsylvania, United States.)
26,418.*Apparatus for breaking pig-iron. (Enterprise Manufacturing Company, of Pennsylvania, United States.)
26,504. Castings for the bearings of friction clutches. T. Cooper and Unbreakable Pulley & Mill Gearing Company, Limited.
27,175. Coating iron, steel, etc., with other metals or alloys. W. J. Brown and H. Foulkes.
27,200.*Moulding machines for foundry use. J. B. Neesham.
27,377.*Manufacturing electric steel castings. G. Fischer and B. Schudel.
27,382. Aluminium alloys. S. P. Hutton.
27,400.*Production of high-grade steel and slag rich in soluble phosphates in an open hearth or electric furnace. Deutsch-Luxemburgische Bergwerks- und Hütten-Akt.-Ges.
27,829.*Alloy of copper and zinc. A. Schmid.
27,836.*Melting metals and alloys. R. S. Wile.
27,864. Gas fired continuous kilns. J. G. Waterfield.
28,135.*Manufacturing tungsten-alloys of high percentage and their introduction into molten metal baths. Th. Goldschmidt (firm of).
28,184. Coating of steel or wrought iron with chilled cast iron. E. L. Davies.
28,269.*Crucibles or melting-pots. Morgan Crucible Company, Limited, and L. C. Harvey.

## Abstracts of British Patent Specifications recently accepted.

11,900 (1911). *Process for Casting Steel in Several Layers.* Aktien Gesellschaft der Briansker Schienen-Eisenbuttenwerke and Maschinenfabriken, Morskaja 46, St. Petersburg, Russia.—Figs. 1 and 2 are respectively a transverse section and a plan view of a suitable apparatus for carrying out the invention; Fig. 3 is a plan view of a modified apparatus and Fig. 4 is a sectional plan view of a portion of an apparatus for casting railway switches. For casting a steel block having two, three or more layers of steel of various chemical compositions, plates or sheets L of soft iron having a small percentage of carbon, are placed in the mould A, (Figs. 1 and 2) of metal or other refractory material, so as to rest on the bottom B of the mould. The plates L are suspended from rods *a* so as to form within the mould a series of chambers C D E. Distance pieces *b* serve to keep the plates L in position at the bottom of the mould, while at the top they are held by tubular pieces or sleeves fixed on the rods *a* (Figs. 1 and 2). To effect a proper bonding of the plates L with the adjacent layers of steel they may be provided with a number of iron pins or projections *p* of rectangular or circular cross section. These pins should not be thicker than plates L and must not project beyond the surface of the plates for more than $\frac{1}{4}$ths of the width of the adjacent layer of steel (Fig. 1). Opening into each chamber C D E is a duct, provided at its upper end with a funnel N through which steel of the desired composition is supplied to the chambers. Plates L and bolts *p* should be, as is customary, carefully cleaned from dirt and other matters, and may be heated if desirable before the steel is cast into the mould. The thickness of plates L should at least be one millimeter, and should be proportional to the width S of each layer of

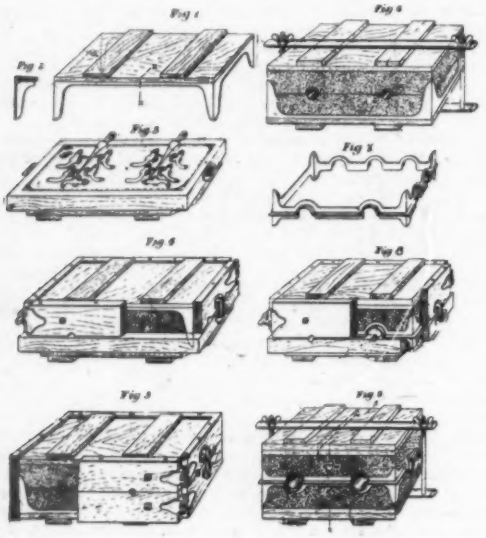



*Apparatus for Casting Steel in several Layers*

steel, but should not be more than three quarters of the width. When the width S varies, or tapers, the above proportions refer to the smallest value of S. The ducts must each be of the same length from the funnel N until they enter the chambers C D E. Masses of steel of different chemical compositions are poured from ladles into the funnels N and passing through the ducts the steel rises into the mould and bonds itself with the plates L but without melting them, so that the several layers cannot mix. When the steel has risen to any desired level in all the chambers the casting is interrupted. In this manner a steel ingot is produced which consists of layers having different chemical composition and connected by sheets of soft iron. The same process is used for producing round or prismatic ingots, having two or more concentric layers C D (Fig. 3). The plates L, bent into a cylindrical, conical or other shape, are arranged concentrically and suspended from a rod *a*. The steel is supplied to the chambers through the funnels N and co-operating ducts.

17,919 (1910). *Improvements in Snap Flasks for Forming Sand Moulds for Castings.* Matthew Harvey, Glebeland Works, Walsall, and Harold Cubley, 55, Bath Road, Walsall.—The object of this invention is a snap flask, and its top and bottom boards arranged so that when the surrounding parts of the flask have been removed from the mould and top and bottom boards, the two parts of the mould will be locked together, and there will be no possibility of their slipping, thus enabling the mould to be poured endways or sideways as may be desired. The important feature is that we employ with the odd side, and with the top and bottom press boards and the surrounding parts of the flask a light, rectangular metal frame made with projections at each of its four corners or other parts, and so arranged that after the surrounding parts of the snap flask, that is, the parts which are technically known as the "drag side" and "cope side," have been removed from the finished mould, this frame, which is situated between the two press boards, remains in position round the finished mould with its four corner or other projections projecting across the parting of the two half moulds and engaging with the corners of the same, so that when the two half moulds and their press boards are clamped together

as is usual, the two half moulds cannot slip out of position with one another, and thus the mould can be poured on edge endwise or sideways as aforesaid. Fig. 1 is a perspective view of the cope press board of a snap flask; Fig. 2 is a sectional side elevation of part of the same taken on line X X of Fig. 1; Fig. 3 is a perspective view of an odd side constructed in accordance with this invention for use with our improved snap flask, this view showing two sprays of patterns lying in the depressions in the odd side; Fig. 4 is a perspective view partly in section showing the drag side of the surrounding part of the snap flask in position on the odd side with the



sand rammed in and pressed by the cope press board; Fig. 5 is a perspective view of the snap flask partly in section, showing the flask turned over from the position represented in Fig. 4 with the cope press board at the bottom and with the cope side of the surrounding part of the snap flask in position on the drag side, and with the other press board pressed on the sand forming the mould; Fig. 6 shows the mould completed with the cope side and drag side parts of the snap flask removed and with the press boards and mould clamped together by an ordinary clamp ready to be turned up sideways for pouring; Fig. 7 is a perspective view of a modified form of the said metal frame which is used in the snap flask according to this invention; Fig. 8 is a perspective view partly in section showing the odd side with the metal frame and drag side thereon together with the cope press board pressing the sand mould on to the odd side; and Fig. 9 shows the two half moulds in position with the frame illustrated in Figs. 7 and 8 clamped together by the top and bottom press boards and the clamp ready to be turned up sideways for pouring.

## Queries.

### Chilled Castings.

We have recently had about 5 cwt. of castings per day similar to the enclosed (6½ in. dia. cogged wheel with chilling in web ¼ in. thick, and also at the cored-out boss). We have carefully examined our scrap, and are confident the trouble does not come from that source. We have melted in a ladle separate pieces of the pig we are using, but have not discovered anything that would give this result, and on drilling the various brands of pigs we use in our mixture each was found to tool very easily. The mixture is 11 cwt. of pig to about 7 cwt. of scrap per charge. We might mention that we have had slight trouble with our ganister, which has been rather too fine and would not hold up to its work. The class of iron referred to comes down in the first charge, but we are quite at a loss to account for such a degree of hardness, as the analysis of our pigs proves the existence of only a small percentage of manganese. Our mixtures have been the same for the last three or four years, as also the coke, but we have not had this trouble before. The cupola seems to be working well, for we don't get thick metal, and the working pressure is ¾ to 1¼ lbs. Needless to say, we are most careful not to have our moulding sand too damp. In fact, there is nothing which we can see that would cause the iron to chill.

"FLUX—MIDLANDS."

*Answer.*—As our correspondent gives us no idea whatever of the irons comprising his present mixture, it is not possible for us to help him in the direction of adjustment of same. His case is certainly unusual. Since this metal only comes down in the first charge, the explanation probably lies in the melting. An inferior coke (the same brand may vary in quality), or too strong a blast with too little volume of air introduced, would result in chilling the iron as it comes down, then falling into an unheated cupola it might, while not being apparently sluggish, be cool enough to be chilled by a mould which otherwise would not give that result. If it is desired, however, to change the mixture, some brand of special pig-iron might be introduced to soften the metal. "Fencamp Softeners" is said to be a suitable brand, as its properties enable it to absorb as much as 80 per cent. of scrap, turning out good grey castings, homogeneous and free from untoolable or spongey parts. This iron is a speciality of the Frodair Iron and Steel Company, Limited, of Fenchurch House, London, E.C., which firm have, we believe, also a good brand of ganister, that should enable him to obviate the difficulty he is experiencing in that direction.

## Trade Talk.

THE postal address of the Anglo-Argentine Iron Company, Limited, is the Hawarden Bridge Works, Shotton, Chester.

MESSRS. A. & E. ROBINSON have acquired the business of Messrs. Robinson Bros., ironfounders, Station Road, Loftus, Yorkshire.

DIXON, POWER & COMPANY, LIMITED, engineers, etc., of Luptons Yard, New Briggate, Leeds, have paid a first and final dividend of 3s. 4½d. in the £.

A FIRE occurred on the premises of Messrs. E. Lucas & Son, Dronfield Foundry and Spindle Works, Dronfield, near Sheffield, on December 5, doing considerable damage to the foundry.

MR. J. D. MACKENZIE, 217, West George Street, Glasgow, has been appointed Scotch agent for Sykes & Sugden, Limited, engineers, of the Spring Places Works, Huddersfield.

MESSRS. HANNAN & BUCHANAN, 75, Robertson Street, Glasgow, have been placed on the War Office list for the supply of engineering instruments.

THE SULLIVAN MACHINERY COMPANY, of Chicago, have established a branch at 814, Salisbury House, London, E.C., under the charge of Mr. H. T. Walsh.

J. J. GUEST & COMPANY, LIMITED, engineers, have now completed and taken possession of their new Charterhouse Works, Northfield Road, Coventry.

THE FARRINGDON WORKS AND H. PONTIFEX & SONS, LIMITED, engineers, ironfounders and coppersmiths, of 46, Shoe Lane, London, E.C., have removed temporarily to 254B, Gray's Inn Road, W.C.

MR. D. ROBERTSON has retired from the firm of Robertson & Robertson, engineers, etc., Perth Foundry,

Perth. The business will be continued by Mr. A. Robertson, under the same style.

It has been decided to voluntarily wind up John Musgrave & Sons, Limited, of the Globe Iron Works, Bolton, for which purpose Mr. H. Mather, 10, Acresfield, Bolton, has been appointed liquidator.

J. Ruscoe & Company, Limited, engineers, of the Albion Works, Henry Street, Hyde, near Manchester, have acquired the business of the Auto Stoker Company, engineers, Ryecroft Street, Ashton-under-Lyne.

The partnership heretofore subsisting between Messrs. J. A. Elliss, C. A. Elliss, F. Elliss, T. D. Elliss, and H. Elliss, Lock Street Foundry, Lock Street, Sheffield, trading as William Elliss & Sons, has been dissolved, so far as regards Mr. Harry Elliss.

Messrs. W. J. Smith, T. Smith, L. Smith, J. J. Smith, and W. B. Smith, carrying on business as engineers and iron and brass founders at the Low Mill Foundry, Barnard Castle, Durham, under the style of William Smith & Company, have dissolved partnership.

Mr. Allan Barton, A.M.I.Mech.E., for many years with Messrs. Tickle Bros., engineers, Wigan, has started in business on his own account as a colliery and general engineer, under the style of Holland & Company, at the Rawlinson Iron Works, Adlington, Lancs.

Mr. N. R. Barker has retired from the firm of Barker & Smith, mechanical and electrical engineers and contractors, Wellwynd Street, Airdrie. The business will be continued by the remaining partner, Mr. Arthur McD. Smith on his own account and in his own name.

At a meeting of the shareholders of Alexander Liggat & Company, Limited, Caledonian Brass Works, Barrhead, held on December 14, 1911, it was decided that the company be wound up voluntarily. Mr. Hugh Muir, 11, West Regent Street, Glasgow, was appointed liquidator.

The partnership hitherto subsisting between Messrs. G. Dunn and G. Briggs, carrying on business as general millwright engineers at Albion Mill, Batley Carr, Yorks., under the style of George Dunn & Company, has been dissolved. Mr. G. Dunn will continue the business under the style of George Dunn & Company.

The partnership heretofore subsisting between Messrs. P. Grandage, H. Barker and J. Dean, carrying on business as machine makers and ironfounders, at Globe Works and Pretoria Works, Manningham, Bradford, under the style of Knowles & Company, has been dissolved. Messrs. H. Barker and J. Dean will continue to carry on business under the style of Knowles & Company.

A large casting has recently been manufactured on Teeside at the works of Richardsons, Westgarth & Company, Limited, Middlesbrough, namely, the main frame and bedplate in one piece for the large set of gas-blowing engines which they are building for the Cargo Fleet Iron Company, Limited. The casting weighs about 42 tons.

A meeting of the members of the Steel Moulders Composition Company, Limited, will be held at 45, Newhall Street, Birmingham, on Monday, January 8, 1912, for the purpose of having an account laid before them showing the manner in which the winding-up has been conducted and the property of the company disposed of.

Professor Ernest G. Coker, of the City and Guilds of London Technical College, on December 9, 1911, lectured on "The Use of Polarised Light as an aid to Determining Stress in Engineering Materials," at a meeting of the Sheffield Society of Engineers and Metallurgists, held at the Sheffield University. Professor Ripper presided.

The partnership heretofore subsisting between Messrs. B. Shorthouse and K. Fisher, carrying on business as engineers and engineering contractors, at 7, Quality Court, Chancery Lane, London, E.C., under the styles of Rowlingsons & Company, The Blackstock Engineering Company, and Shorthouse, Fisher & Company, has been dissolved.

In the Chancery Division Mr. Justice Swinfen Eady on December 9, 1911, had before him a petition for the reduction of the capital of Kell & Company, Limited, ironfounders, of Gloucester and Ross. It was proposed to reduce the capital of the company to £12,500 in ordinary shares, and to issue debentures for the £12,000 preference shares, and to redeem the debentures from time to time. The debentures were to be of £50 each. His Lordship sanctioned the reduction as proposed.

Sir Robert Hadfield, lecturing recently, on "Cingalese Iron of Ancient Origin," at the Royal Society, described some of the specimens of ancient iron from the buried cities of Ceylon, among them being: (1) a steel chisel, 5th century A.D.; (2) an ancient nail, probably of same place and date; (3) a bill-hook. This date had been verified by one of the Fellows of the Royal Society, Dr. A. Willey, F.R.S. Examination of the chisel showed:—Composition: C., traces; Si., 12; S., .003; P., .28; Mn., nil; Fe., 99.3 per cent.; specific gravity, 7.60.

Henry Wallwork & Company, Limited, ironfounders, engineers, and machine makers, of Red Bank, Manchester, have issued a pamphlet representing the latest development in connection with high efficiency gearing for power transmission. It introduces for consideration a new feature in connection with this type of gear, viz., guaranteed performance. The company have over ninety gears going through their shops at the present time, including two 200 h.p., three 100 h.p., and one 300 h.p. gears, all electrically driven and covered by definite guarantees. Messrs. Wallwork have made definite determinations in connection with the temperature rise and efficiency of such gear, and have now standardised a complete line from ¼ to 200 h.p., every size being guaranteed as to efficiency, temperature, and overload. It is possible to produce these gears to a standard specification with no greater variation than one or two per cent. between individual gears.

In deciding a case which came before him in the Chancery Division of the High Court, recently, Mr. Justice Swinfen Eady made rather an interesting pronouncement with reference to a liberal allowance for depreciation in the value of plant and machinery being necessary before a satisfactory balance-sheet could be arrived at. "In the course of ascertaining the profits of a business where power machinery is in use," said his Lordship, "it is, in my opinion, absolutely essential that a liberal allowance should be written off for depreciation, in addition to the sums which may be expended in repairing or in renewing parts, before you can arrive at the net profits of the business. There can be no profit until a proper sum, varying with the class and the life of machinery and plant in use, and the nature of the business, has been written off as depreciation. Machinery may be properly kept up, parts may be renewed, and other things may be done in the course of a year's working, but its saleable value is yearly on the decrease, and this must be allowed for under all circumstances. Trade and industrial machinery rapidly becomes obsolete, being superseded by more modern kinds, and in a few years may for this reason become worthless to cope with increasing competition. This point must be observed if any business is to be conducted on a sound financial basis."

We are informed that owing to family reasons, in consequence of the death of the late Lord Airedale, a new company has been formed to acquire and carry on the business of the Monk Bridge Iron and Steel Company, Limited, of the Monk Bridge Iron Works, Leeds, and John Butler & Company, Limited, of the Stanningley Iron Works, Stanningley, near Leeds, enterprises for long associated with the Kitson family. The company retains the name of the Monk Bridge Iron and Steel Company, Limited, and the directors are:—Mr. F. J. Kitson, Gledhow Grove, Chapel-Allerton, Leeds, chairman; Lord Airedale, Gledhow Hall, Leeds; Mr. E. H. Jeffreys, Greenholme, Burley-in-Wharfedale; the Hon. R. D. Kitson, Leeds (director of Bolckow, Vaughan & Company, Limited, and the North-Eastern Railway Company; Mr. H. H. Kitson, St. Ann's Grange, Burley, Leeds (all directors of the Monk Bridge Iron and Steel Company, Limited, the vendor company). The share capital is £500,000, divided into 250,000 cumulative 6 per cent preference shares of £1 each and 250,000 ordinary shares of £1 each, and the vendor company offered for subscription an issue of 250,000 preference shares, taking the whole of the ordinary shares in part payment of the purchase money. The business of John Butler & Company, Limited, will be continued

as a separate company under the control of this company, which will acquire the whole of the debenture stock and shares issued by them. The purchase price of the Monk Bridge Works is £500,000, including land and stock, payable by 250,000 fully paid £1 ordinary shares in the new company and £250,000 in cash. The scheme is, in effect, a reconstruction, involving the winding up of the old company, and a transfer to the new company.

## Personal.

THE late Mr. C. Wardlow, of Messrs. S. & C. Wardlow, crucible steel makers, Sheffield, left estate sworn at £68,707 gross.

THE late Mr. H. Halsted, formerly of the East Street Iron Foundry, Chichester, left estate returned at £92,026, with net personalty £71,507.

THE late Mr. F. Braby, of Fredk. Braby & Company, Limited, left estate of the gross value of £182,542, with net personalty £154,178.

THE Council of the Iron and Steel Institute have nominated Cav. G. E. Falck, President of the Associazione fra gli Industriali Metallurgici Italiani, as an honorary vice-president of the Institute.

MR. W. S. SMART, who has left the Birmingham Corporation Gas Department to become general manager to W. J. Jenkins & Company, Limited, Retford, has been the recipient of a presentation from the Gas Department.

MR. W. H. DORMAN, of W. H. Dorman & Company, Limited, engineers, brassfounders and ironfounders, of Foregate Street, Stafford, has been the recipient of presentations from the officials and men on the occasion of his retirement.

MR. ANDREW BUTCHART, who occupied the post of secretary of the Barrow Hematite Steel Company, Limited, Barrow-in-Furness, for 22 years, has been appointed to a seat on the board of directors. Mr. Butchart was succeeded as secretary a short time back by Mr. A. F. Mason.

THE Council and Court of Sheffield University have approved the proposal to confer upon Professor A. McWilliam, the degree of Doctor Metallurgy in Substantia of the University, in recognition of his valued services to the University and of his researches in connection with the metallurgy of steel.

MR. L. MUNNS has been appointed secretary of Cammell, Laird & Company, Limited, of Sheffield and Birkenhead, in succession to Mr. F. J. Maw, who has retired owing to failing health. Mr. Munns joined the firm some eleven years ago as chief accountant, but has latterly filled the dual position of commercial manager and assistant secretary.

## Deaths.

MR. B. JONES, at one time owner of the Riverside Engineering Works, Newport, died recently.

MR. F. B. WRIGHT, of Wootton Court, Warwickshire, a director of the Butterley Company, Limited, died recently.

MR. G. LEEK, a director of Geo. Leek & Sons, Limited, of the Hope Street Foundry, Salford, Manchester, died recently, aged 60 years.

THE death occurred on December 1, 1911, at the age of 83 years, of Mr. W. Thomlinson-Walker, of Clifton Grove, York. Mr. Thomlinson-Walker, who was a native of the city, succeeded his father in the business of an ironfounder at the Victoria Iron Works, Walmgate.

THE death is reported of Dr.-Ing. Emil Blum, the President of the Berlin Branch of the Verein Deutscher Ingenieure, and managing director of the Berlin-Anhaltische Maschinenbau A.-G., of Dessau, at the age of 67 years. He was also the President of the German North-Eastern Trade Association for Iron and Steel.

## New Companies.

BAYFORD IRON WORKS, LIMITED.—Capital £35,000 in £1 shares.

THAMES METAL COMPANY, LIMITED.—Capital £15,000 in £1 shares.

KENT & MITCHELL, LIMITED.—Capital £600 in £1 shares, to carry on the business of engineers, etc.

STOCK CONVERTER COMPANY, LIMITED.—Capital £8,000 in £1 shares, to carry on the business of iron and steel makers, etc.

LAWLER, AYERS & COMPANY, LIMITED.—Capital £15,000 in £1 shares, to carry on the business of engineers, etc.

W. E. WHITESIDE & JAMES CASLAKE, LIMITED.—Capital £3,000 in £1 shares, to carry on the business of metal workers, etc.

H. M. ASHTON, LIMITED.—Capital £3,000 in £1 shares (2,000 preference), to carry on the business of mechanical engineers, etc.

DICKINSON MACHINE TOOL COMPANY, LIMITED.—Capital £12,000 in £1 shares. Registered office: Devonshire Works, Keighley, Yorks.

OSWALD CARR, LIMITED.—Capital £500 in £1 shares, to carry on the business of engineers, etc. Registered office: Oak Works, Headingley, Leeds.

RANKINE & BROWN, LIMITED.—Capital £2,000 in £1 shares, to carry on the business of ironfounders, etc. Registered office:—47, West Nile Street, Glasgow.

UNIT ENGINEERING COMPANY, LIMITED.—Capital £1,000 in £1 shares (500 deferred). Registered office: 45, Victoria Buildings, St. Mary's Gate, Manchester.

MILBURN KERCKHOVE SYNDICATE, LIMITED.—Capital £100 in £1 shares, to carry on the business of ironmasters, etc. Registered office: 57, Gracechurch Street, E.C.

WHITEHOUSE & ROSE, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of metal manufacturers and merchants, brass and ironfounders, iron and steel merchants, wire drawers, tube manufacturers, etc.

LONDON INSTRUMENT COMPANY, LIMITED.—Capital £525 in 500 preference shares of £1 each and 500 deferred of 1s., to carry on the business of engineers, etc. Registered office: Westholme, Drayton Road, Hillingdon Heath, Middlesex.

CLIFTON & BAIRD, LIMITED.—Capital £15,000 in 8,000 preference and 7,000 ordinary shares of £1 each, to acquire and carry on the existing business of machine tool makers, engineers, and ironfounders. Registered office: Empress Works, Johnstone.

ORDNANCE COMPANY, LIMITED.—Capital £52,750 in 45,000 ordinary shares of £1 each and 155,000 deferred shares of 1s. each, to carry on the business of manufacturers of guns, gun carriages, weapons, projectiles, etc. Registered office: 199, Piccadilly, W.

BARRETT & COMPANY (CARDIFF), LIMITED.—Capital £5,000 in £1 shares, to acquire the business carried on at West Side, East Bute Dock, Cardiff, as Barrett & Company, and to carry on the business of ship repairers, ironfounders, engineers, etc. Registered office: West Side, East Dock, Cardiff.

WILLIAM ROLLINSON & SONS, LIMITED.—Capital £10,000 in £1 shares (5,000 5½ per cent. cumulative preference), to take over the business of ironfounders, millwrights, and general engineers, carried on by William Rollinson & Sons, at Church Street, Old Basford, Nottingham, and to adopt an agreement with W. O. Rollinson, S. Rollinson, and J. A. Rollinson.

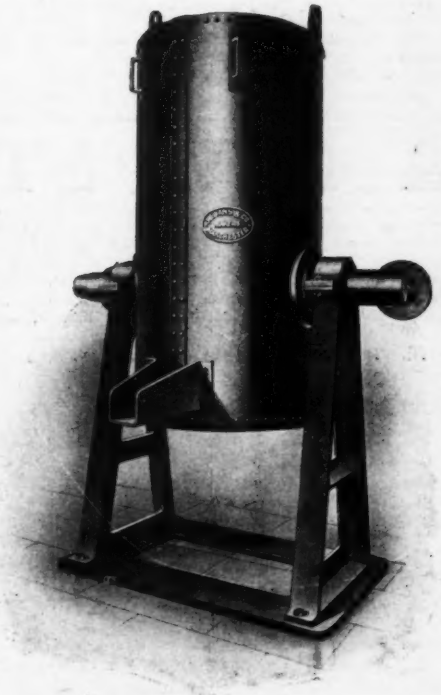
HADLEY ENGINEERING COMPANY, LIMITED.—Capital £250,000 divided into 150,000 6 per cecnt. cumulative preference shares and 100,000 ordinary shares of £1 each, to acquire and combine the businesses hitherto carried on by Joseph Sankey & Sons, at Hadley, Shropshire, by Thomas Tilling, Limited, at Peckham, and by W. A. Stevens, Limited, of Maidstone.

AS SUPPLIED TO THE ADMIRALTY, WAR OFFICE, COLONIES, AND FOREIGN GOVERNMENTS.

# THE Cupola.
# Evans's Rapid.

**Foundries Completely Furnished.**

## EVANS'S NEW CUPOLETTE
**For Emergency Work.**



**James Evans & Co.,**
**Britannia Works,**
***Blackfriars,***
***MANCHESTER.***

Telegrams: "LADLES, MANCHESTER."

## Parliamentary Notes.

### War Office Steel Orders.

COLONEL SEELY informed Mr. A. Henderson, in the House of Commons recently, that the figures for iron and steel castings obtained from private contractors and for those produced in the Arsenal were as follows:—

| | Trade. | Ordnance Factories |
|---|---|---|
| 1909 ... ... ... | 101 tons ... ... | 2,425 tons |
| 1910 ... ... ... | 294 tons ... ... | 2,314 tons |
| 1911 ... ... ... | 164 tons ... ... | 2,072 tons |

The foundries of the Royal Arsenal, the Under-Secretary added, were fully occupied during the periods in question, and the castings given to the trade could not have been made in them.

### Castings for the Admiralty.

MR. HENDERSON also addressed questions to the Admiralty in the Commons as to the amount of iron and steel castings obtained from private contractors for the dockyards at Portsmouth and Devonport, and whether such castings could have been made in the foundries of the Department.

DR. MACNAMARA, who replied, said: The figures are as follows:—

| Six months ending | Portsmouth | | Devonport. | | Totals. | |
|---|---|---|---|---|---|---|
| | Iron. Tons. | Steel. Tons. | Iron. Tons. | Steel. Tons. | Iron. Tons. | Steel. Tons. |
| 30th June, 1909 | 26 | 272 | 5 | 148 | 31 | 420 |
| 30th June, 1910 ... | 35 | 270 | 3 | 116 | 38 | 386 |
| 30th June, 1911 ... | 15 | 132 | 2 | 153 | 17 | 285 |
| | 76 | 674 | 10 | 417 | 86 | 1,091 |

The dockyards, DR. MACNAMARA added, have no facilities for making steel castings or iron castings of special quality. The quantity of iron castings of ordinary quality bought from the trade is inconsiderable.


**FOUNDRY CUPOLAS!**

**FOUNDRY LADLES!**

Finest Workmanship and Materials.

**SEND for QUOTATIONS**

Our PRICES will interest YOU!

**The DERBY BOILER Co., Ltd.,**

DERBY.

**A NEW STEEL BARROW**

(PATENTED)

**"BRABY'S BALANCED BARROW."**

The Handiest and Cheapest Barrow in the market. Specially designed for coal, dross, ashes, etc. Its capacity is **25 per cent. greater** than the ordinary style, yet it can be wheeled with **half the labour**, and can be emptied **much more quickly**. It is a **perfectly balanced** barrow, and a full load can be **easily wheeled by a boy.**

**NOTE.—This Barrow can be taken right up to mouth of furnace and the ashes drawn into the barrow direct from the furnace.**

The "B.B.B."

**BRABY** for high grade **STEEL**
SHEETS & PLATES up to 15 FEET LONG.
RANGE of GAUGES 8 to 30 W.G.
RANGE of WIDTHS 12 to 60 in.

**BRABY** for improved wrought **STEEL**
BARROWS. BOGIES. TRUCKS.
GUTTERS. PIPES, &c.

**BRABY** for Iron and **STEEL**
ROOFS and BUILDINGS.

**BRABY** for unbreakable **STEEL**
SASHES, CASEMENTS, and PUTTYLESS ROOFLIGHTS.

**BRABY** for galvanized corrugated **STEEL**
SHEETS: "EMPRESS" & "SUN" BRANDS

**FREDERICK BRABY & Co. Ltd.,** Eclipse Iron & Galvanising Works & Steel Sheet Rolling Mills, Petershill Road, GLASGOW.

Show Rooms and Aluminium Warehouse, 124, St. Vincent Street, Glasgow.
Rustless Iron, Galvanising and Copper Works, FALKIRK.

**Also at London, Deptford, Liverpool, Bristol, Belfast and Dublin. CONTRACTORS to BRITISH and FOREIGN GOVERNMENTS.** Teleg.—"Braby, Glasgow."

# PURE METALS

**and ALLOYS. FREE from CARBON.**

**TITANIUM THERMIT**

**for**

**SOUND. STRONG, CLOSE-GRAINED CASTINGS.**

**Also FERRO VANADIUM and FERRO TITANIUM.**

Full Particulars and PRICES from—

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Telegrams: "Fulmen, London."
Telephone: 3749 Central,

**27, Martins Lane,**
**Cannon Street, E.C.**

**Works: 210a, Bow Road, E.**

# ELDERS FOUNDRY COKE

**AS SUPPLIED TO THE**
**BRITISH**
**ADMIRALTY DOCKYARDS.**

**The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.**

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

## Elders Collieries, Ltd., Cardiff.

## PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

| Metals. | End Dec., 1911. | End Dec., 1910. |
|---|---|---|
| Iron—Scotch pig warrants ton | *56/6 | *55/10½ |
| —Middlesbro' warrants .. ton | 50/9 | 49/10½ |
| —W.C. M/nos Bessemer ... ton | 67/0 | 66 6 |
| —Stock, Scotch ... ...tons | 1,000 | 1,000 |
| Copper—Chili bars, GMB ton | £63 17 6 | £56 2 6 |
| —Stock, Europe and afloat tons | 56,569 | 83,797 |
| Tin—English ingots ... ton | £205 0 0 | £175 10 0 |
| —Straits ... ... ... ton | £200 10 0 | £175 10 0 |
| —Stock, London, Holland, U.S.A., and afloat ...tons | — | 20,846 |
| Lead—English pig ... ton | £16 2 6 | £13 11 3 |
| Spelter—Ord. Silesian ... ton | £26 15 0 | £24 0 0 |
| Quicksilver (75lb)... bottle | £8 2 6 | £8 0 0 |
| Antimony—Regulus .. ton | £27 10 0 £28 0 0 | £28 0 0–£29 0 0 |

* Settlement price.

### Castings.

In the Cleveland district the following are the nominal rates current for castings :—

| | £ s. d. | | £ s. d. |
|---|---|---|---|
| Columns (plain) ... ... ... ... | 6 10 0 | to | 6 15 0 |
| Pipes, 1½ to 2½ in. ... ... ... ... | 4 17 6 | to | 5 2 6 |
| ,, 3 to 4 in. ... ... ... ... | 4 10 0 | to | 5 0 0 |
| ,, 5 to 8 in. ... ... ... ... | 4 7 6 | to | 4 10 0 |
| ,, 10 to 16 in. ... ... ... ... | 4 7 6 | to | 4 10 0 |
| ,, 18 to 24 in. ... ... ... ... | 4 7 6 | to | 4 10 0 |
| Chairs ... ... ... ... ... ... | 3 12 6 | to | 3 15 0 |
| Floor plates (open sand) ... ... | 3 0 0 | to | 3 2 6 |

### Scrap.

The quotations for scrap, subject to market fluctuations, are as follows : Heavy wrought (mixed), £2 9s. 0d. ; light wrought, £1 5s. 0d. ; heavy cast, £2 6s. 0d. ; all per ton, f.o.b., London. Copper (clean), £57 10s. 0d. ; brass (clean), £41 10s. 0d. ; lead (usual draft), £14 10s. 0d. ; zinc, £21 5s. 0d. ; all per ton delivered merchant's yard.

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Mr. William Russell, of Salford, died on December 8, 1911, at the age of 66 years. A native of Glasgow, he had resided in Salford for 40 years, and was one of the founders of the firm now known as Fletcher, Russell & Company, Limited, engineers and ironfounders, Palatine Works, Warrington.

We have received from The British-American Specialities Company, 10-12, Ivy Lane, London, E.C., a specimen of their "Gaynor Swastika" self-filling fountain pen. This handy pen is extremely simple in construction, and requires only the depression of a small projection to empty the interior rubber sack, while the release of the pressure, on the pen-point being placed in an ink pot, fills it ready for use.


PLUMBAGO,
Foundry Blacking,
Terra Flake,
NEW CORE GUM,
CRUCIBLES.

. . CARRIAGE PAID QUOTATIONS. . .

WM. OLSEN, COGAN STREET, HULL.

S.B. Empire Time Recorders.

Are BRITISH MADE throughout.

ONE MACHINE REGISTERS
ANY NUMBER OF EMPLOYEES
ANY NUMBER OF TIMES
DAY AND NIGHT SHIFT SEPARATELY
REGULAR AND OVERTIME SEPARATELY.
EACH DEPARTMENT SEPARATELY
GIVES WEEKLY OR FORTNIGHTLY
TABULATED CARD.

*WRITE FOR OUR NEW DESCRIPTIVE BOOKLET ON TIME AND JOB COSTING.*

The Stockall Brook Time Recorders, Ltd.,
43, Market Street,
Huddersfield.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
*Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.*
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams : "LOWOOD, DEEPCAR."

*Established 1863.*

# JAS. DURRANS & SONS,

## Phœnix Works, Penistone, Near Sheffield.

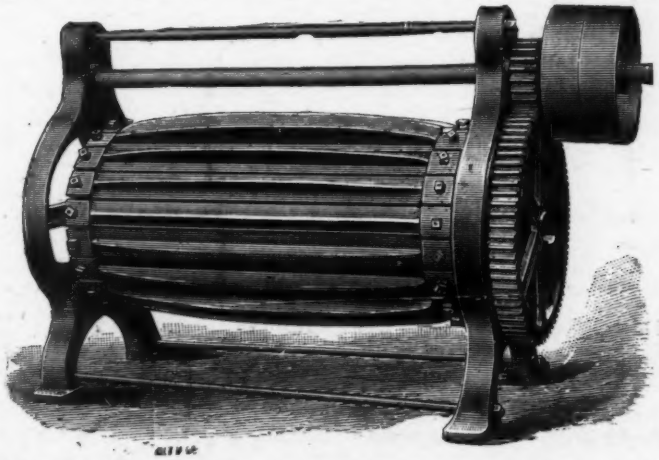
**Manufacturers of all**

## *FOUNDRY EQUIPMENTS*

**COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST**

**Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.**

## Improved Foundry Rattler or Fettling Drum.



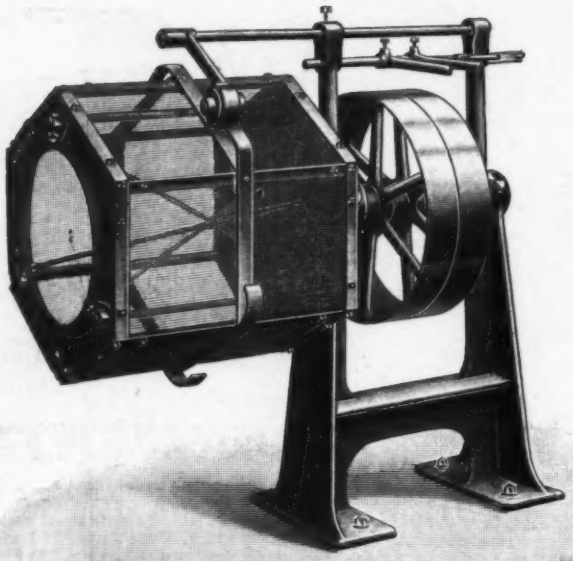
**These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.**

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

# Rotary Sand Sifter.



How are you sifting your Sand? Are you using the expensive method of hand riddling? If so write for particulars of our Sand Sifters, they save their cost in a few months. The above illustrates the single-ended Rotary Machine, fitted with our special screen knocking arrangement that prevents the sand clogging and doubles the efficiency of the machine. Capacity with ¼ inch mesh, 3 tons per hour. Power required ½ h.p.

**Full particulars of other types of Sand Sifters will be posted on application. The largest selection on the market.**

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MOULDING MACHINES. CORE MAKING MACHINES.
CORE OVENS. SAND BLAST APPARATUS.
ABRASIVE WHEELS. FETTLING MACHINES.

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Phillips, J. W. & C. J.
Thwaites Bros., Ltd.
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Marshall & Co. Horace P.
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Jackman, J. W., & Co., Ltd.
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Olsen, Wm.
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Buffalo Forge Co., Ltd.
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Keith, J., & Blackman, Co., Ltd.
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Olsen, Wm.
Sykes, James.
Walker, I. & I.
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Williams, John (Birmingham Sand) Ltd.

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Elders Navigation Collieries.

**Coke Breakers.**
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Olsen, Wm.

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Hall, Charles, & Co.
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Olsen, Wm.
Wilkinson, Thos. & Co.

**Core Gums.**
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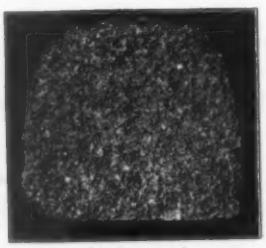
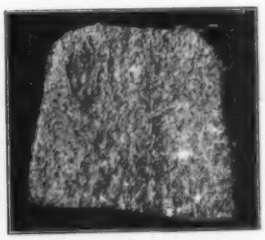
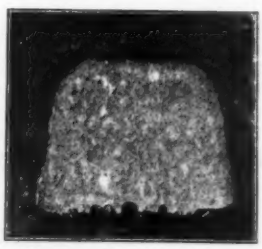

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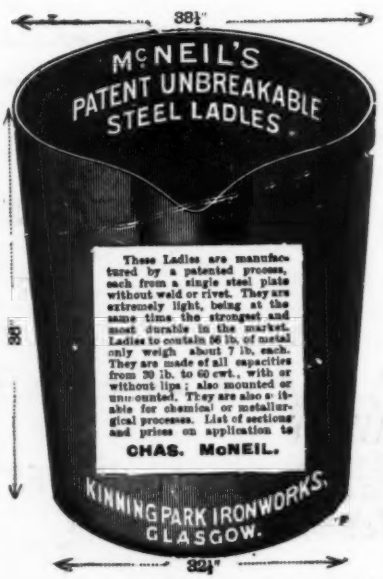
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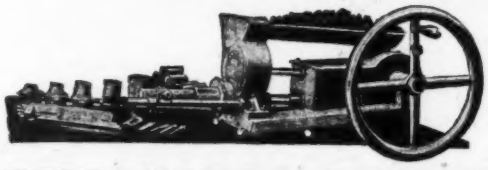

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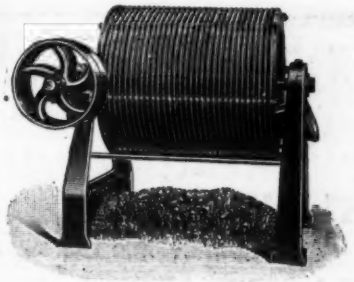

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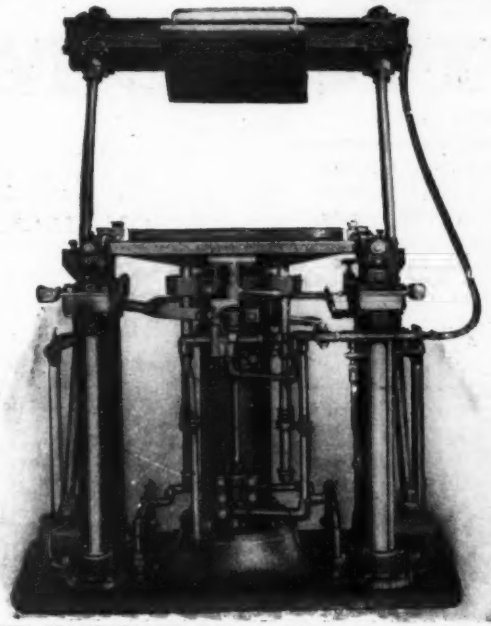

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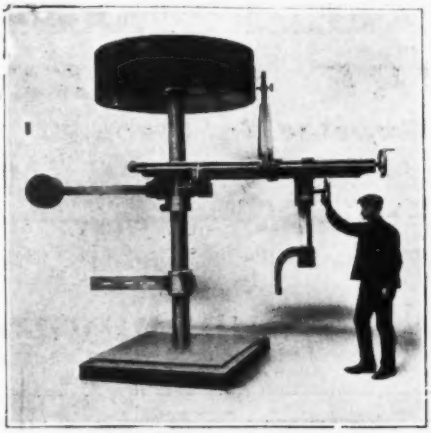

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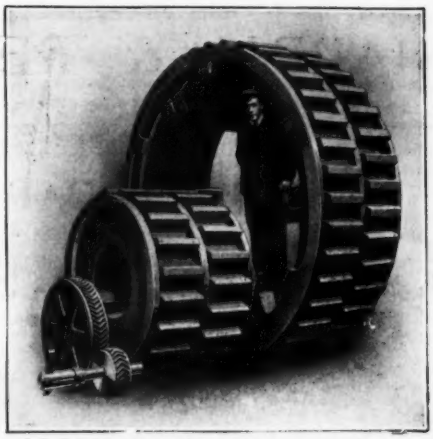

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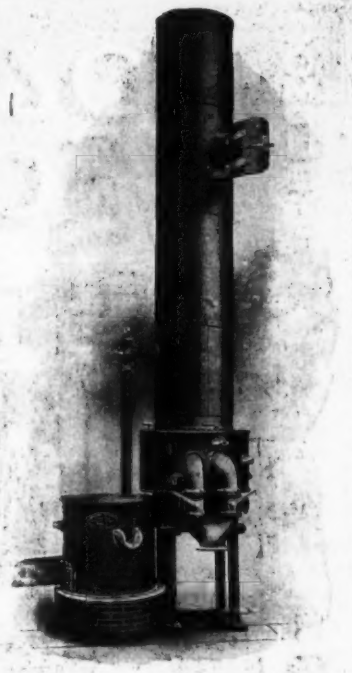

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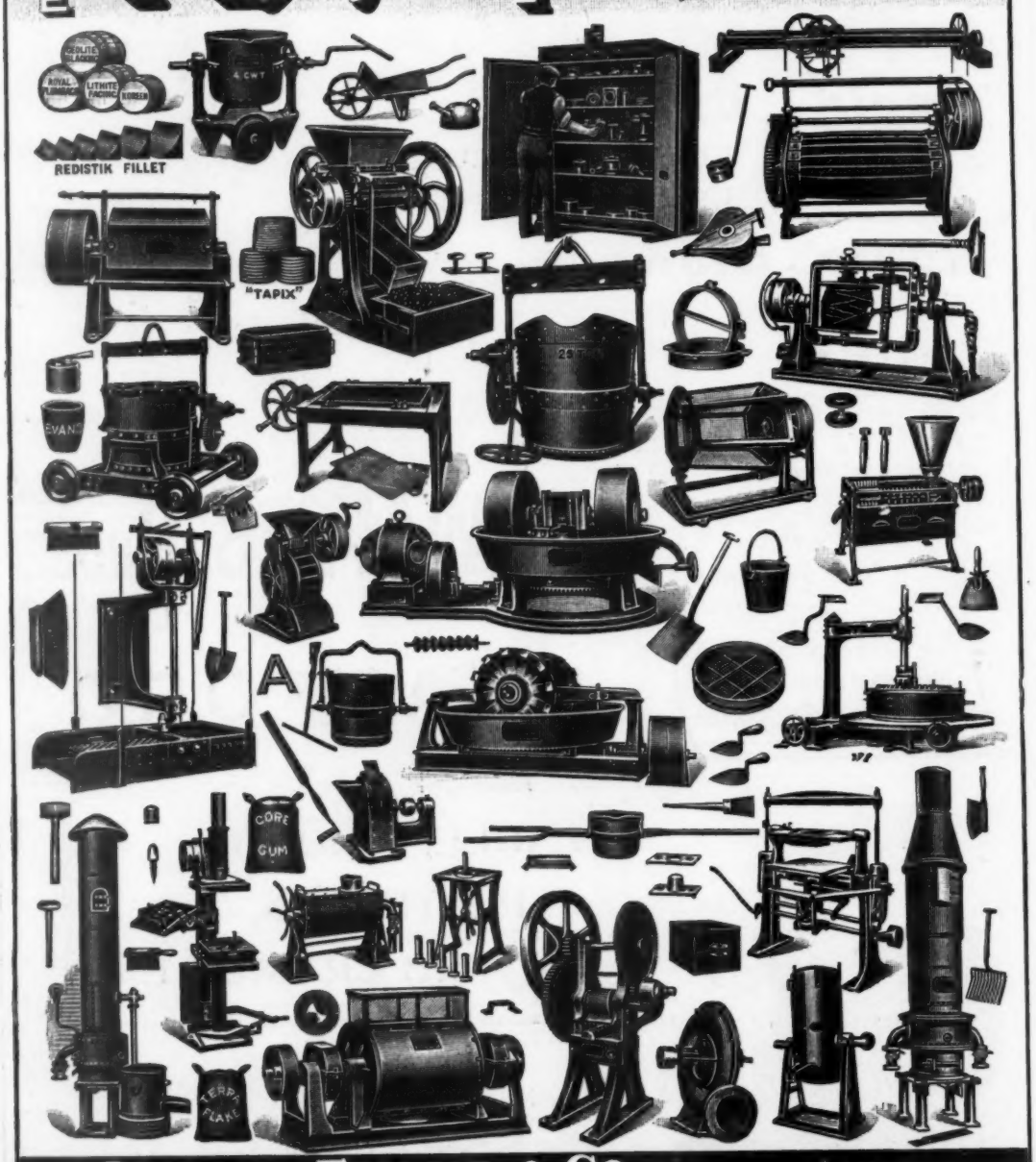


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